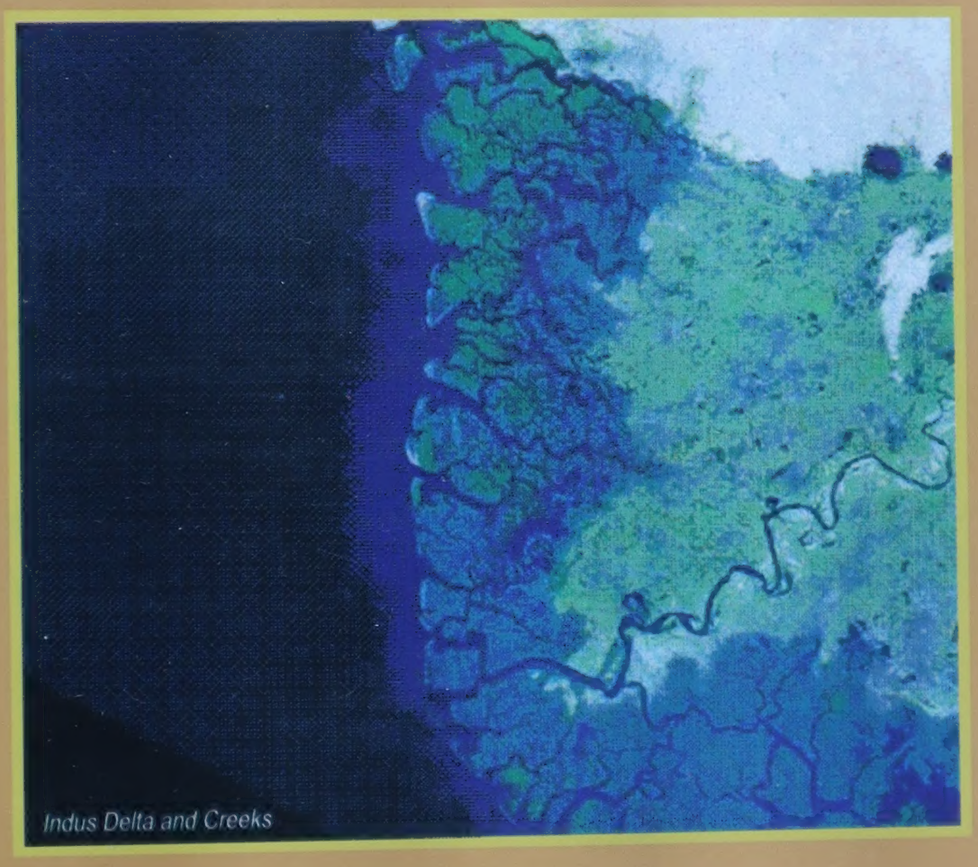
IMPACT ASSESSMENT: CONSEQUENCES OF SEAWATER INTRUSION IN PAKISTAN



Indus Delta and Creeks

By

M.H. Panhwar

Updated by

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IMPACT ASSESSMENT

Consequences of Seawater Intrusion in Pakistan

Funded by
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This Impact Assessment Study was carried out by the renowned scholar and researcher **Mr. M.H. Panhwar**. While the final draft of the study was being prepared sudden death of Mr. M.H. Panhwar came as shock and great loss to people of Sindh.

The current document has been updated by Prof. Dr. B.K. Lashari and Mr. Ehsan Leghari.

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Ambreen Nawaz

SUMMARY

Seawater intrusion in general is considered intrusion of seawater in the land wards coast and beyond. This is a generalized definition and does not take into account the changes, which in case of Pakistan have taken place in Arabian Sea itself and also along the seawards as well as land wards coast. Even then these three areas can be further subdivided in terms of increase in salinity in various parts of the Arabian Sea in past half century. This division includes: *Salinity of Persian Gulf; Salinity of red Sea; Salinity of Arabian Sea; Salinization of Sindh Coast possibly in a width of at least 50 kilometer in last half century; Salinization of fresh water lakes connected with sea; Salinization of dry Indus bed due to intrusion of sea; Salinization of ground water along both banks of the River Indus in terms of width in kilometers due to seepage of seawater and tides horizontally into aquifer, which was not saline before; and Salinization of natural lakes due to non availability of fresh water, continuous evaporation and exchange of salts with saline groundwater.* All these are discussed in various chapters of the report. However, some features of the report are narrated in the following paragraphs.

The construction of Kotri Barrage in 1955 and Guddu Barrage in 1962 in Sindh Province and number of link canals and barrages in Punjab Province have made the situation of seawater intrusion serious. Average annual water flow to the sea was 73 MAF (million acre feet) until 1961, which reduced to 50 MAF up to 1991, but then fell down to 8.4 MAF in 1999 and 0.74, 1.92 and 2.15 MAF in 2000, 2001 and 2002 respectively and the same average follows till 2005 (ranges between 2-2.15 MAF). Along with its silt load also came down almost to 10% of that 1955.

Chapter 2 mentioned the water release to downstream Kotri. During negotiation between India and Pakistan on water dispute in 1960, with the assistance of the World Bank, both countries agreed that minimum 17 MAF water has to be discharged into the sea. Pakistan Government has failed to execute it. In 1991 Water Accord between the Pakistan Provinces negotiated by the Government of Pakistan elucidating that 10 MAF of water is allowed to go into sea with minimum 5000 cusecs (cubic feet per second) on any day of the year. Finally in 2005, Arbitrators were appointed for the purpose and came out with the figures that 8.7 MAF with minimum 5,000 cusecs on any day of the year. Seawater intrusion is mainly connected with low discharge of fresh water and silt into the sea and has converted Sindh coast from river dominated to sea dominated.

Further, various creeks are now widening, water in the creeks has developed salinity more than seawater, hitting 38,000, 41,000, and 42,000 ppm in different creeks against 36,000 ppm of Arabian Sea, while previously only 20 years back it was 27,000 ppm at the maximum. Sindh Government planned to utilize 16,000 acres of land for prawn farming, only to be abandoned, when coastal waters changed salinity to 35,000 ppm within a few years

In addition, silt which is rich in calcium, Magnesium, Nitrogen, Phosphate, Potash (though seawater has enough of these elements), Copper, Zinc, Manganese, Iron, Boron, Molybdenum and many minor compounds needed to promote Phytoplankton and Zooplankton on which fisheries and Arabian sea productivity is flourished, which is only second after Gulf of Oman . Thus the contribution of the Indus water discharge as well as silt have major role in its productivity, which have fallen in time and may further reduce in future.

Chapters five onwards put light to all the following aspects in detail.

Due to seawater intrusion there has been loss of mangroves, fisheries, specially shrimps and Palla, and the fish catch per unit effort is less than 1/3rd now than it was 30 years back. Due to pollution the coast is no longer attracting people for recreation like, boating, swimming etc. Due to salt water intrusion sub-aerial delta is also eroding.

Sea level has risen 165 mm since 1850. This was not felt before, as silt brought by the Indus was being thrown back on the land by waves and tidal actions and land level was always kept on rising. In absence of silt, it is now sea, which is encroaching on the land. A sea rise of 2 meters in twenty first century has been observed.

Biological threats of seawater intrusion are loss of mangroves and species. Productivity of Arabian Sea will also reduce in absence of nutrients brought by the Indus waters. Already, it is witnessed that red algae killer of fishes and birds in large number- as it was not common before. This will probably increase further.

Fresh water lakes in coastal districts are already degrading in terms of production.

Avicenna Marina has been affected badly and mangrove production has reduce to only 16% as it was 40 years back. Lake of mangroves, has already affected crustacean and they will further deteriorate. Wildlife is also equally affected as discussed in Chapter-VII.

Many coastal archaeological sites have already been flooded or attacked by tides and have deteriorated as discussed in Chapter XI. This is heavy cultural heritage loss.

The major problem of inland is seawater entering into the dry bed of Indus tides going upstream by nearly 100 Km. The Indus bed is about 20-22 feet below the surrounding and tides are about 10 feet high and therefore, tides water travel up the Indus bed and from there seeps in adjoining lands in a wide length and seeps into adjoining areas turning groundwater saline. Groundwater under 2.0 million acres is thus affected. The saline water rising in shape of salinity to surface has destroyed pastureland and many cropped areas.

This report also presents wide scenario in brief. A number of maps and illustration have been added to make present scenario clearer and allow the reader to understand the problem clearly, which is causing serious havoc in Sindh Province.

Finally the report concludes that:

In the coastal area uncertainly and absence of water in the river bed combined with mismanagement of water resources has caused enormous hardship and there is little or no prospect of change in near future. Very dim hope exists for the improvement of environments of coastal and marine fisheries and related species at least for some time. There is also no prospect of increasing income of coastal communities unless a "Crash" program is launched.

Further, if rule of law is to prevail then following actions are needed:

- Allowing at least 8.7 MAF of water downstream of Kotri with no less than 5,000 cusecs discharge on any day.
- Banning use of illegal nets and stopping illegal trawling.
- Strictly observing one month ban on prawn fishing during their breeding season.
- Abolishing contract system
- Ending occupation of lakes etc. by Rangers
- Fixing royalty on oil production in Badin District and using it for local improvement.

Chapter 1

POSITION OF THE INDUS RIVER DISCHARGE FORM 1922 TO 2006 AND ITS SILT LOAD

Indus River Tributaries

The tributaries of Indus are; Jehlum, Chenab, Ravi, Beas and Sutlej on the left bank and Kabul on right bank. Gomal, Gaj, Baran also supply some water during rainy season, but being mostly rain-fed flowing for a few days annually, they are not considered as perennial tributaries. Gaj causes heavy floods with heavy silt load once in about 20 years.

Riverain area downstream to Kotri barrage

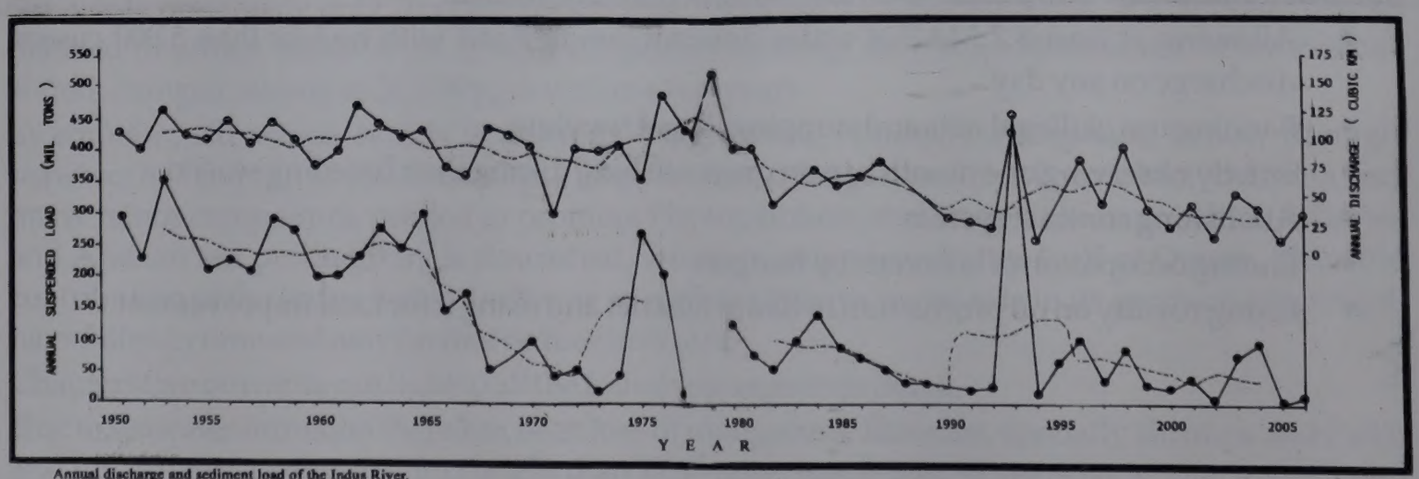
The total riverain area of Sindh from Guddu barrage to the sea is 2,112,000 acres, of which about 630,786 or nearly 30% falls between Kotri and the sea, lying between the flood protective embankments, which them-selves are from 5 to 16 kilometers wide at different places.

Soils of riverian area

Soils of riverain area are very fertile due to nutrients in silt deposited during inundation season. Up to 1991, this was the best area of Sindh for growing Banana and Cucurbitae family melons etc., but all this was destroyed due to non-availability of water in the river stream from which, users pumped water for cultivation through out the year. There were also riverain forests which dried up in 1970s after commissioning of Tarbela dam. Riverain fisheries also got severe setback because of lack of water.

Time period of maximum discharge of silt and water by the Indus

Maximum discharge of silt and water usually is from May to October, when 80% river discharge occurred. The mean discharge of the Indus ranges from 5,550 to 7,500 cumecs or 196,360 to 264,000 cusecs, but this is annual average, after construction of many barrages and dams.



Annual discharge and sediment load of the Indus River.

Discharge to sea averaged or exceeded 100 km per year and suspended load exceeded 200 million tons with average of 225 million tons in 1947. It was less then 60 km 3/year in 1960s and 1970s. The current situation is described in following chapters.

Annual suspended load of silt at Sehwan for various discharges of the river Indus

Month	Discharge cubic meters per second	Annual silt load in (metric tons)
May	30,000	70
June	40,000	125
July	50,000	150
August	60,000	200
September	70,000	225
October	110,000	400

Source WAPDA

Indus River catchment in length

It is # 10 largest river in the World on # 10. In discharge has drainage area of 970,000 sq. km., from height greater than 4,000 meters. Mountainous area of its catchments is 400,000 Sqm. Its length in alluvial plains to delta is 1,000 Kms.

The Indus discharge patterns

- Maximum discharge is in 6 months, May to October carrying more than 80% water.
- Its mean discharge 5550-7500 discharge in cumecs (cubic meters per second).
- Mean discharge during flood season is 20,000 cumecs.
- It carried maximum silt load 600 million tons of which about 250 million tons used to discharge in to the sea annually. In upper reaches of the Indus minimum 80 metric tons of sediment settled annually. A substantial portion also deposited in the river bed and canals in Sindh down stream of present Guddu barrage, which raised level of alluvial plains in Sindh by about 14 feet (5.12 meters) in the past 4,000 years and nearly twice as much since Amrian times or 4,000 BC as between 4,000 to 2,000 BC, there was more rainfall even 2.5 times as compared with the present time 2005.
- Of the sediments, entering at Guddu, about 50% settle in the Indus plains consisting of coarser materials with relief of about 9 meters. The remaining fine sediments reach to the sea and build the delta, which has progressed 80 kms in 2000 years i.e., 4 kms per century.
- Mangla dam was completed in 1967, Tarbela 1974. The result is they reduced silt load to the sea drastically.

The Indus delta shore line length

The delta width of the Indus is about 320 kms, the other bigger than it are given in table.

Showing delta length 10 major rivers of the World

Sr. No.	Name	Length in Kilometers
1.	Ganga	730
2.	Mississippi	610
3.	Lena	580
4.	Volga	470
5.	Mekong	500
6.	Orinoco	470
7.	Niger	430
8.	Yangtze Kiang	410
9.	Irrawaddy	390
10.	**INDUS**	**320**

Drainage basin of other rivers and Indus

Drainage basin of Indus is much smaller than many others and in order of highest to lowest it stands number 6.

1. Amazon	2. Ganges	3. Yantze Kiang	4. Lena
5. Hwang Ho	**6. Indus**	7. Mississimppi	8. Volga
9. Irrawaddy	10. Orinoco	11. Shattar Al Arab	12. Niger
13. PO	14. Nile	15. Red	16. Chao Phraya
17. Mackenzie	18. Godavari	19. Senegal	20. Ord

Annual runoff major rivers of the World

In annual runoff Indus is much less than others and in order lowest to highest world rivers stands as No.9.

1. Ganges Brahamputra	2. Orinoco	3. Mississippi	4. Parana
5. Irrawaddy	6. Mekanzi	7. Niger	8. Danube
9. Indus	10. Red	11. Sao Francisco	12. Nile
13. Hwang Ho	14. Mahanadi	15. Rhone	16. PO

Chapter 2

SEAWATER INTRUSION
PROBLEMS OF THE COASTAL AREAS

The following are some of the out standing problems of the coastal area connected with reduced discharge of the Indus river waters. Lack of water in the river Indus for 10 months a year has degenerated environment in following ways:

a) Destruction of mangroves;
b) Reduction in crustacean (Prawns, Lobsters and Crabs) and other fishes, especially Hilsa, Catfish etc. and total destruction of Oysters;
c) Encroachment of predators (Carnivorous fishes) in the creeks and reduction of edible fishes;
d) High salinity water in the creeks causing reduction in the total fish catch;
e) Destruction of hatchery sites of Crustacean and Hilsa;
f) Severe reduction of catch per unit effort (boat and manpower) and has reduced to 33%;
g) Due to silt carried by the Indus in the past the land started advancing into the sea at the rate of four kilometers per century and now the reverse process has started and erosion of land between creeks has started;
h) Nearly for the past 25 years, lack of river water with less silt, has resulted into wave and wind erosion and all 17 creeks of the Indus along the coast have flattened, their mouths have widened and depth at the outlet to the sea is reduced;
i) The Sindh coast, which was river-dominated has now become wave dominated due to strong winds;
j) Silt that Indus water carried suspended and dissolved nutrients in the Arabian Sea for a distance of many dozen kilometers. The nutrients contained Calcium, Nitrogen, Phosphorus, Potash, Magnesium, Sulphur, Copper, Zinc, Manganese, Boron and Molybdenum, which produced Phytoplankton and Zooplankton, which were a rich natural feed for fish and have now reduced to 10%;
k) Seawater has started encroaching in the inland through the bed of the river Indus and the coastal Talukas are being abandoned. According to Sindh Government 1.2 million acres have turned saline and have been abandoned. Independent sources calculate it to 2.0 million acres. Farmers and pastorals have moved out and population has decreased. Only very poor fishermen are left behind. Agricultural fields have also been abandoned. People have migrated to big cities, where they can't adjust and have become the prey of socio-economic problems as they do not have any particular skill and no education. In brief the coastal and sub-coastal inland-ward environments have been destroyed. The productivity of the Arabian Sea has been badly affected. By discharging large volume of water in to the sea, the Indus used to create low salinity in the creeks. The creeks are now more saline than the sea itself hitting 3.8 to 4.2% salts, against 3.6% of the Arabian sea;
l) Seawater itself which had salinity of 35,000 ppm (parts of salts per million parts of water) has increased to 36,000 ppm;
m) The temperature of seawater has risen affecting not only the growth of fish fauna, but certain species have either migrated or become extinct;
n) Half a million acres of mangroves have been destroyed as human being, Camels, Buffaloes,

Sheeps and Goats were depending on their fruit. Fodder, feed, fuel, honey and timber for house construction have been affected causing serious unemployment problems;

o) No research study has been done to find out whether diversion of water for irrigation was more economical than the loss caused by lack of water in the coastal deltas of Badin, Thatta and Karachi and also loss of economic potential. A balance has to be maintained between the two alternate uses of water. This study could still be undertaken if funds are available at IIRE;

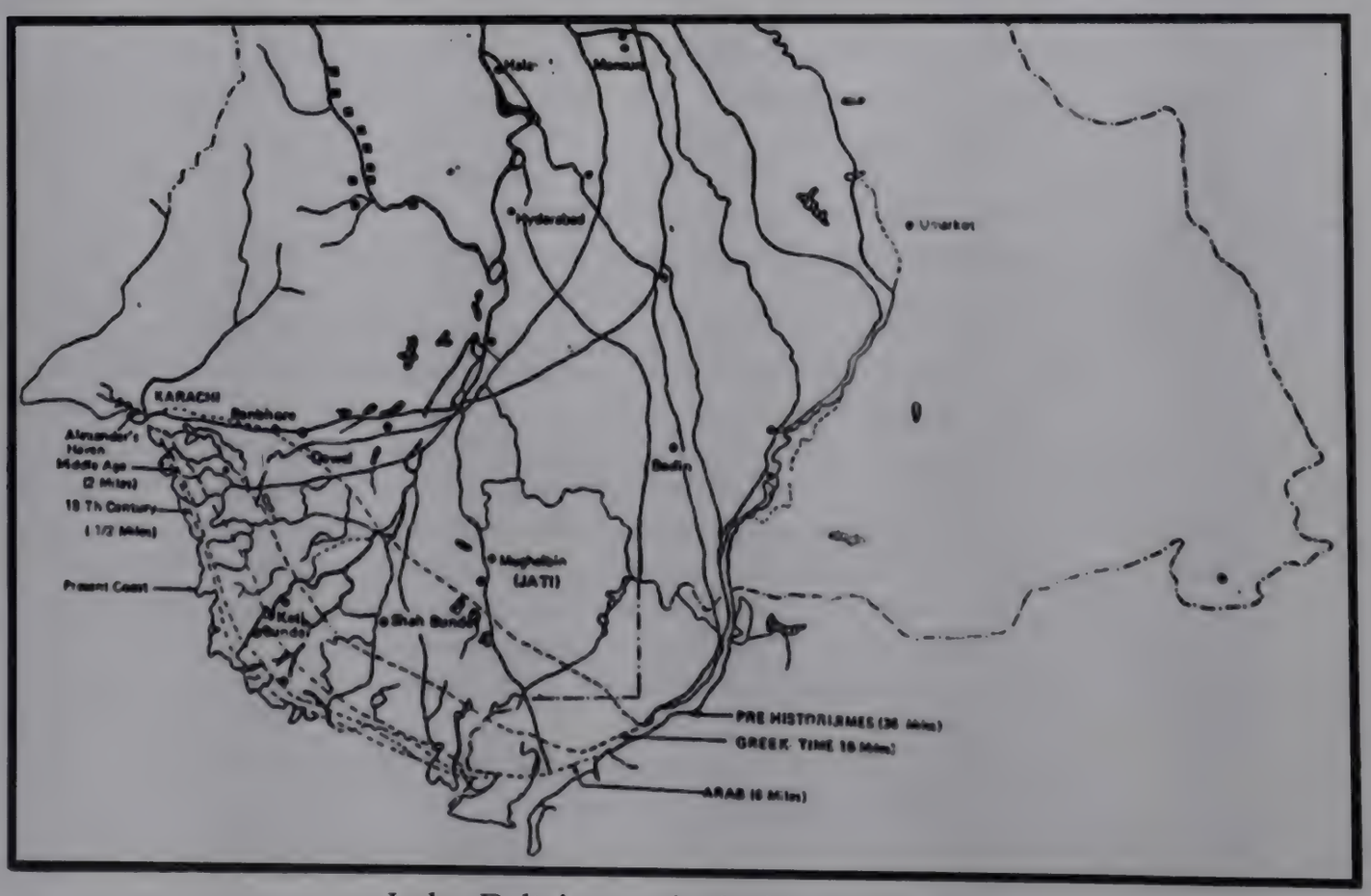
p) During 1960 negotiations with India, Pakistan asked for minimum 5,000 cusecs to flow into the sea during the months of October to June and large quantity of water form July to September to make total availability to the extent of 17 million acre feet of water to stop sea intrusion. As per 1991 Water Accord there is a demand for 10 MAF of water to be allowed to flow into the sea during the year. This has not yet been settled yet. A recent Arbitration which is binding all Provincial and Federal Governments of Pakistan has recommended 8.7 MAF to go to the sea and on no day less than 5,000 cusecs. Though it will not resolve the problem of coastal area but at least improve it a little.

Water intrusion - history

a) Advancing of delta at rate of 4 kms a century has been reversed;

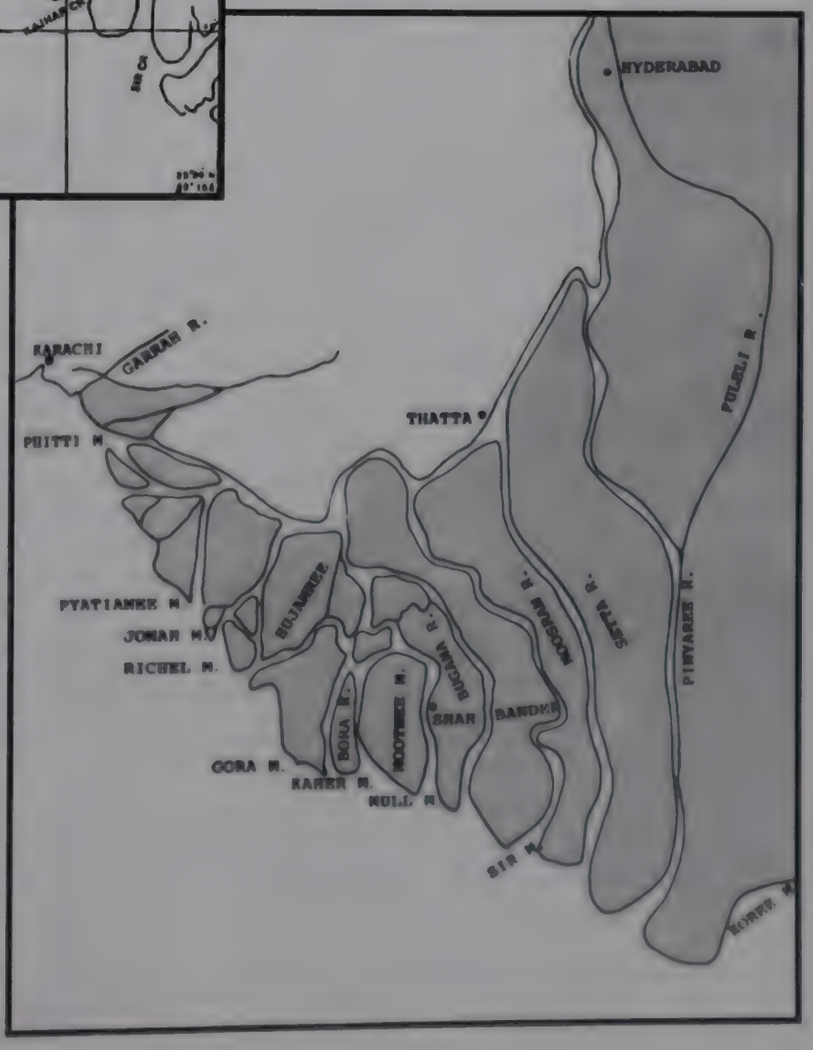
b) Water diversion started after 1875 AD and its impact on Sindh was felt in the 19th century. Sir Evans James Commissioner in Sindh in 1899 left a note for his successors that diversion of water in the Punjab is going to impose construction of barrages in Sindh by causing water shortages and reducing level of water in the Indus;

c) The delta, ports and harbors have been changing. The Keti Bander having population of 25,000 has been reduced to 5,000 in past 20 years;



Indus Deltaic coast in the historical past

Major creeks
in the Indus deltaic region



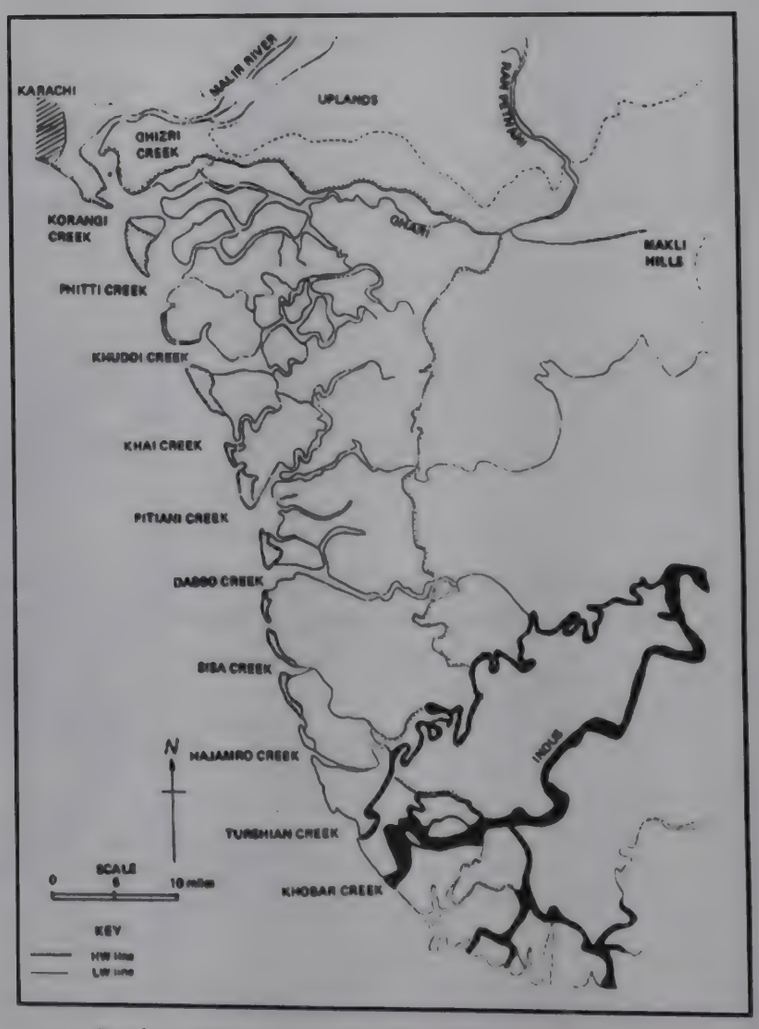
Condition of Indus Delta in 1817
showing about thirteen months
at the Arabia Sea

Ruins of Lahri Bandar at Kadiro Creek

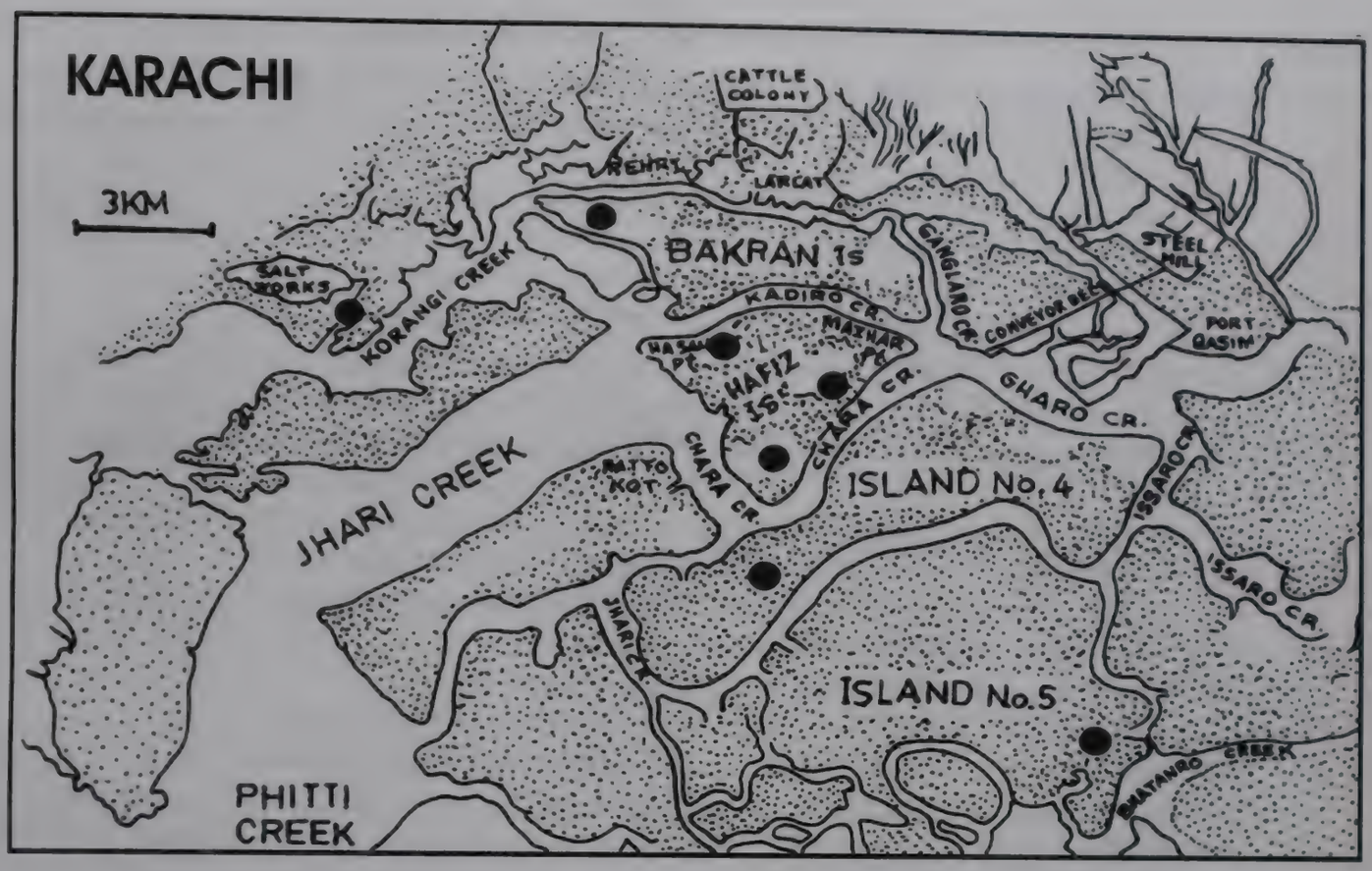
d) Sub aerial and sub-aqueous area has lost population and productivity;

e) Position of Indus delta as compared to other delta of the world area, silt load, water discharge and wave energy has been discussed in Chapter-I;

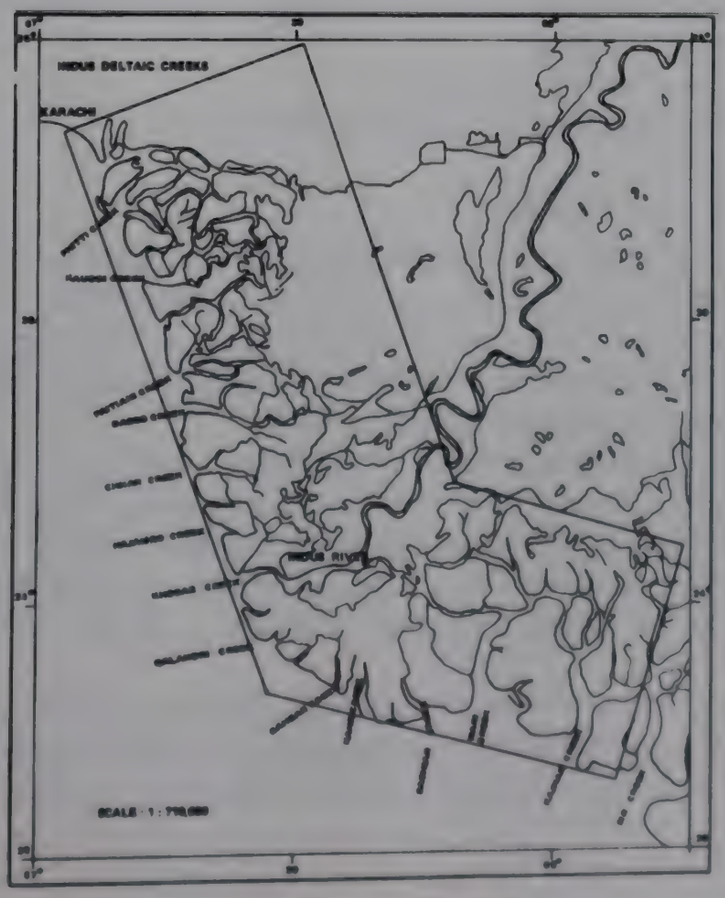
f) Oceanographic Archaeology will indicate how many ancient coastal towns are submerged or destroyed. In the past 150 years sea has risen by 165mm. Warming caused by burning of fossil fuels is proceeding at a very fast rate, glaciers are melting, seawater evaporation will increase, but rainfall in Tropics and Sub-tropics will decrease and there will be more rain fall in Temperate zone, causing drought in first case and floods in the other. In both cases misery for people. Rise of seawater will submerge some coastal areas.



Indus River and Indus Deltaic Creeks



Interconnection of Creeks



Indus Deltaic Creeks

Adverse effects of water diversion and sea intrusion in the deltaic area

a) Deltaic erosion has started and anticipated consequences in long term will be that sea will encroach upon the land and in 500 years - may be where it was 2500 years ago;
b) Loss of zoological species;
c) Loss of botanical species;
d) Reduction in fish catch per unit effort;
e) Destruction of natural hatcheries;
f) Encroachment of carnivorous predators of fish and crustacean in the creeks;
g) Loss of nutrients brought by the river silt containing. Calcium, Magnesium, Nitrogen, Potash, Phosphate, Copper, Zinc, Iron, Manganese, Boron, Molybdenum and many other trace elements needed by Zooplankton and Phytoplankton and thus severe reduction in the productivity;
h) Ground water turning saline. The process of seepage of tidal water from the river bed has already lead to abandonment of vast areas of agriculture and pasture land;
i) Soils turning saline and abandonment of about 1.2 million acres of land;
j) Natural pastures loss and pastorals moving out of area;
k) Rise of water temperature discussed in chapters that follow;
l) Grazing ground for Camel, Sheep, Goat, Buffaloes, Cows etc. destroyed;
m) Decreased influx of nutrient rich river water has affected off shore fisheries;
n) Although annual catch of fishes increased 7 folds between 1950 to 1981, but effective number of boats had increase 23 folds, i.e., annual catch per boat had fallen down to nearly 1/3rd. The number of boats is still on the increase in spite of advice of FAO against it;
o) Cutting down large sediment load has particularly caused great potential for high coastal erosion by waves and winds;
p) Loss of lagoons due to deltaic erosion;
Damage to structures, coastal installations sand housing.

Seawater intrusion and prawn farming

In 1980 the government of Sindh found whole coastal area suitable for seawater prawn farming. Coastal waters had salinity varying between 17,000 to 27,000 ppm, from annual Summer Indus flood to next year's monsoons and it was considered highly suitable for Crustacean like Prawns, Lobsters, Crabs and also ideal for maturity of Hilsa or Pallah. Below 17,000 and above 27,000 ppm prawn farming under ordinary technology gets set back.

Government allotted 16,000 acres to some 80 candidates and one of them started studies for specialized hatchery techniques, prawn feed, prawn processing and monitoring water quality. However by the end of 1985 due to lack of water discharge from the Indus, salinity of coastal water near the proposed farm area increased to 35,000 ppm and project was abandoned with the loss to many allottees, specially to those who spent vast amount on studies.

There are still areas, where above salinites suitable for prawn farming prawn farming above salinities could be existed, but due to low water flows in the Indus and people being not aware of new and suitable areas, prawn farming under present technology is not feasible.

Salinity of seawater

Salinities 36,000-36,500 ppm are now found in Arabian Sea against previous 35,000 ppm, due to following reasons:

- Intense evaporation;
- High salinity water discharge from Red Sea and Persian Gulf;
- North Arabian Sea is arid like lands surround it and has scanty rainfall;
- No large rivers are flowing in it except the Indus;
- Reduction in Indus water discharge is going to increase salinity to the same limit as Red Sea and Persian Gulf i.e., 37,500 to 40,000 ppm and destruction of extinction of many fauna and flora;
- Deeper seawater has lower salinity than surface water during hot dry period, due to evaporation, but higher during fall months as surface water gets diluted by rainwater and river discharges;
- Salinity of water along shore of Karachi at present is 35,500 to 36,900 and has risen to 41,000-42,000 ppm in back waters, and tidal creeks.

Chapter 3

DELTA, COAST LINE AND COASTAL ZONE

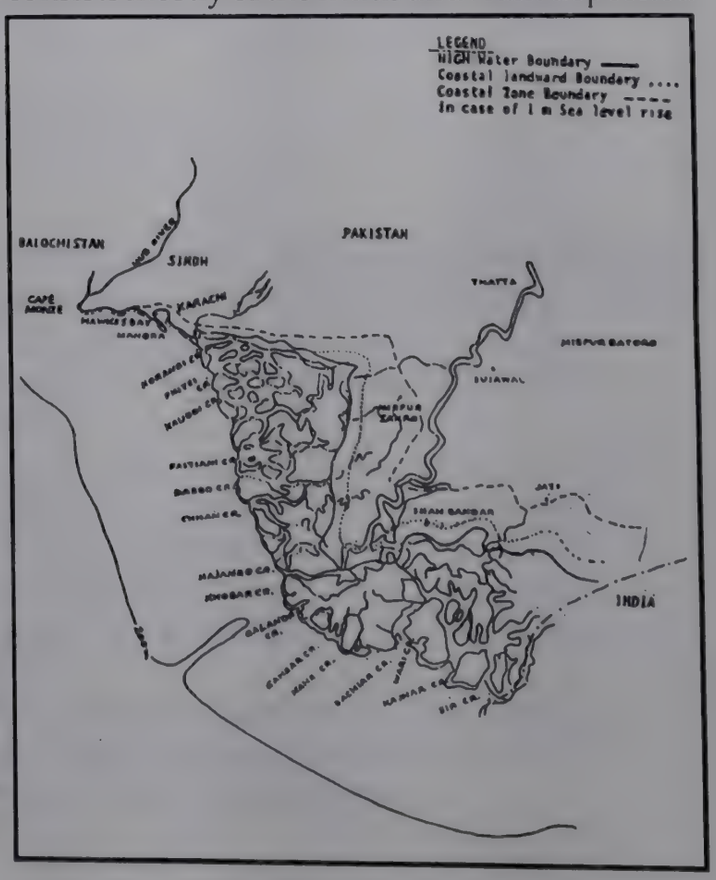
Tidal and non-tidal coastal area

The coastal area can clearly be defined as tidal and non-tidal zones. The tidal zone changes from month to month and year to year, due to action of tides, winds and discharge of drainage water into estuaries. Silt carried by river Indus into the Arabian Sea is in part deposited back into various creeks as well as the whole coast. The Sindh coast was river dominated during the entire Holocene, but the process has been reversed in the past 30 years and now it is wave dominated. Waves have been eroding the coast gradually and the signs are visible from the widening mouth of the creeks. Mangrove and other vegetation are being destroyed by erosion. Dunes are forming encroaching mangroves and flat land. It has been found that creek mouths are now silting. The fish catch in the creeks has been reduced. Predators of fish have increased. Silt brought by the Indus carried minerals and nutrients, which helped in development of phytoplankton and zooplankton, natural sources of fish feed. In general the amount of fish available in Arabian Sea is reducing in absence of silt and nutrients brought by the Indus and would continue.

The natural geo-resource like soil is under serious threat. Coastal soils are rich though saline, but they can grow all kind of halophytes on seawater and therefore are very important in terms of geo-economic resource. There is a possibility of oil and gas development of the coast in Sindh. Geological formation of Eocene era below the present alluvium of coastal area show the presence of oil and gas in the continental shelf as well as inland areas of Badin and Thatta districts. Not many minerals can be found in the continental shelf, as it consists mostly of the Indus alluvium deposited year after year during a few million years of the recent geological past and in a width of more than a hundred miles or more.

Land ward areas

Land ward areas out side the tidal reach, is mostly under canal irrigation. The whole exercise is aimed at collecting the information for future developments. It is felt that sea-creeks, estuaries, mangroves, halophytes, sea-weeds, fisheries in the creeks and shrimp and other fish farming, can create a great potential for development in future. With the development, the area can support more people per square kilometer than in the irrigated areas. The climate and environment as resource for development are other factors to be recognized. The coastal climate especially of Ghora Bari, Keti Bander, Shah Bander and Jati close to the sea is most suitable for raising value added crops like; Cashew, Avocado, Macadamia and all other semi-tropical crops.



Landward Limits of Sindh Coastal Zone

17 Creeks of Sindh Coast

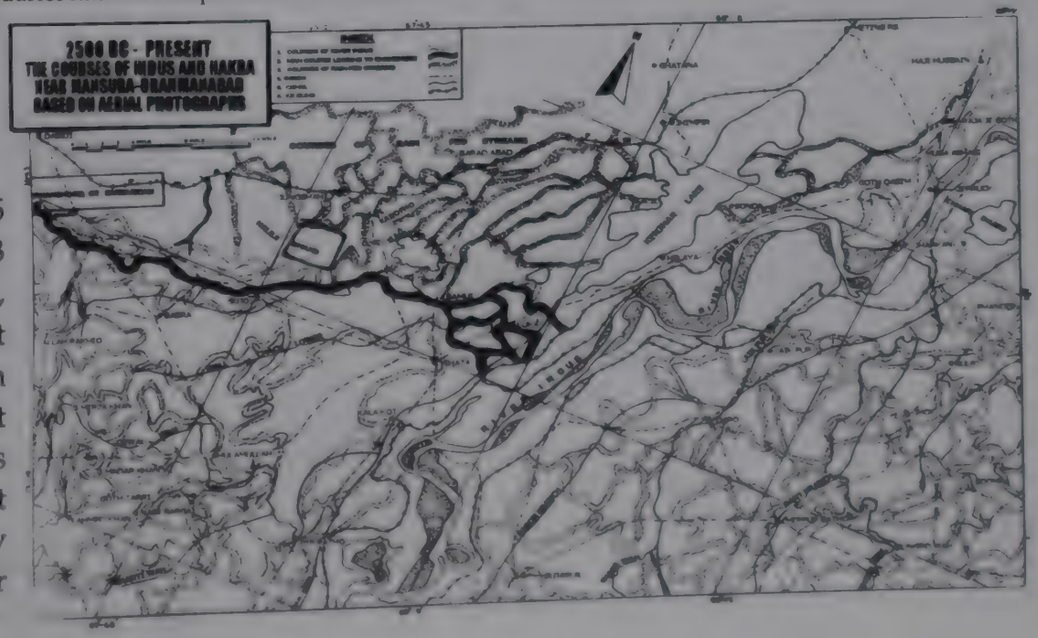
There are 17 creeks of Sindh Coast of which Liari is rain-fed the others are old beds of the Indus. Their names and characteristics are listed below:

Creeks

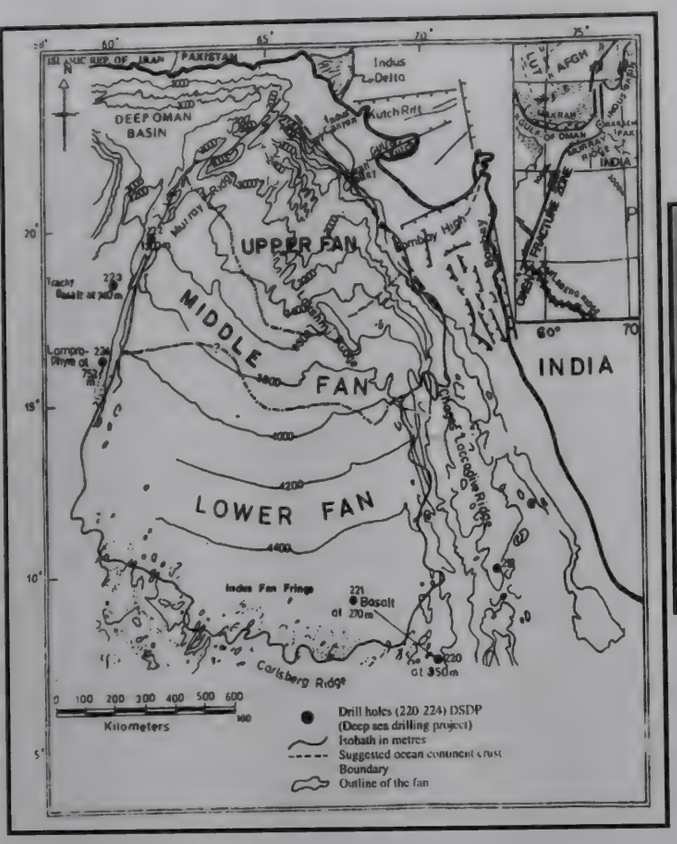
S. No.	Name of Creek	Length in Kms	Width in Meters	Depth in Meters
1.	Korangi	20	1350	15
2.	Gharo-Phitti System	28	250-2500*	6-11.3
3.	Chan Waddo	16	360-700*	20
4.	Khuddi	20	2600	30
5.	Khai	25	900-1900*	6
6.	Paitiani	22	1175-1900*	5
7.	Dabbo	25	1200-1470*	8
8.	Bhuri	14	700-720*	6
9.	Hajamro		400-490*	5
10.	Khobar (main branch of Indus)	20	-1200	8
11.	Qalandri	20	800-1000*	3
12.	Kahr (Mutia minor creek nearby)	15	1400	4 to 5.5
13.	Bachair (Mai a minor creek nearby)	30	-1700	4
14.	Wari	19	-2500	6
15.	Kajhar	26	-2000	6
16.	Sir	90	2000-5000*	6

* Shows width at entrance to the sea. It has increased in recent years due to wave domination. In case of increase in width, depth has also decreased, showing accumulation of eroded material at the mouth of creek. In case of active beds silt carried by river water accumulated in front of mouth of creek and reducing it depth as in case of Khobar. Depth of estuary is maximum where no erosion has taken place as in case of Khuddi and Korangi. Estuaries had more depth than creek mouths and are better suited for navigation.

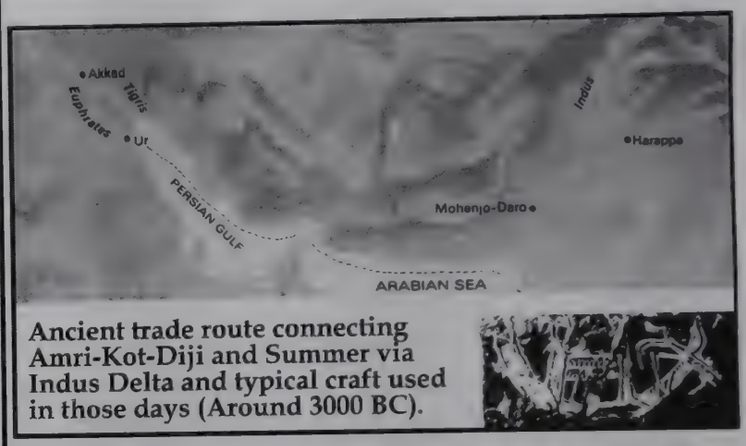
Historical position of sea coast in the past 2500 years



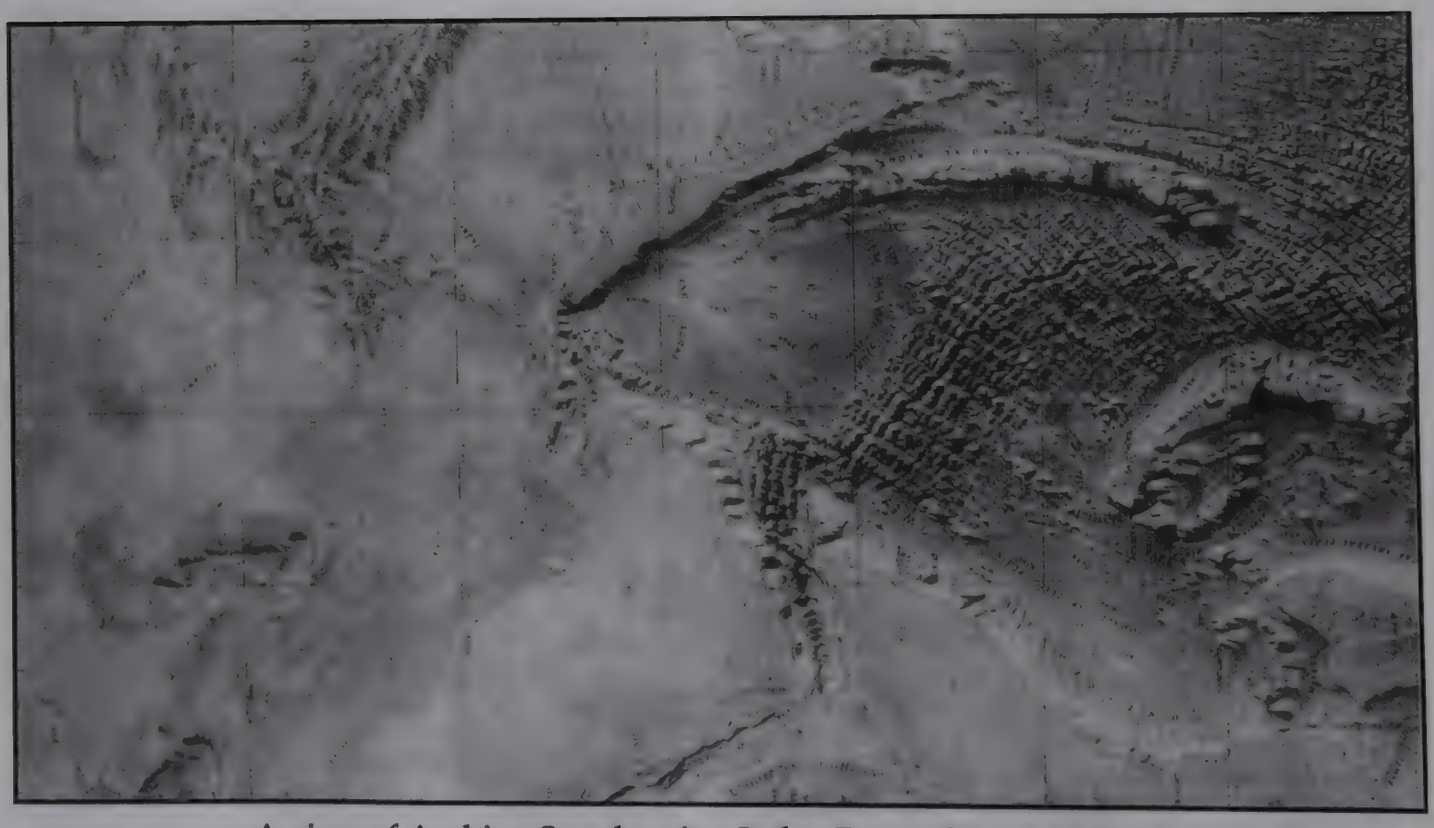
With an average of 225 million tons of silt in 73 million acre feet of water, it has been observed that the volume of silt in water was 0.6%. This silt suspended in water was taken by river current many miles away towards the sea, major



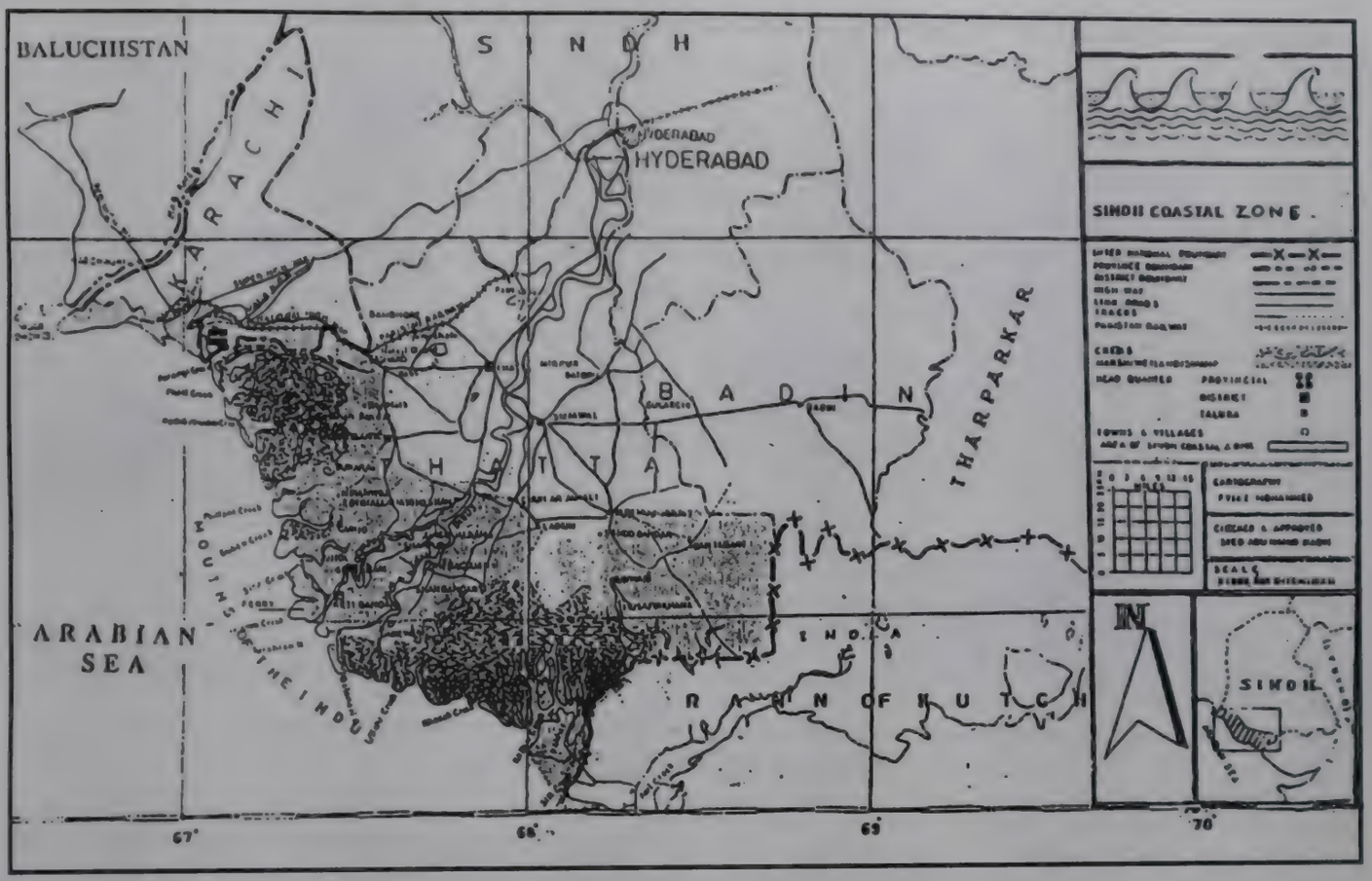
Northern Arabian Sea



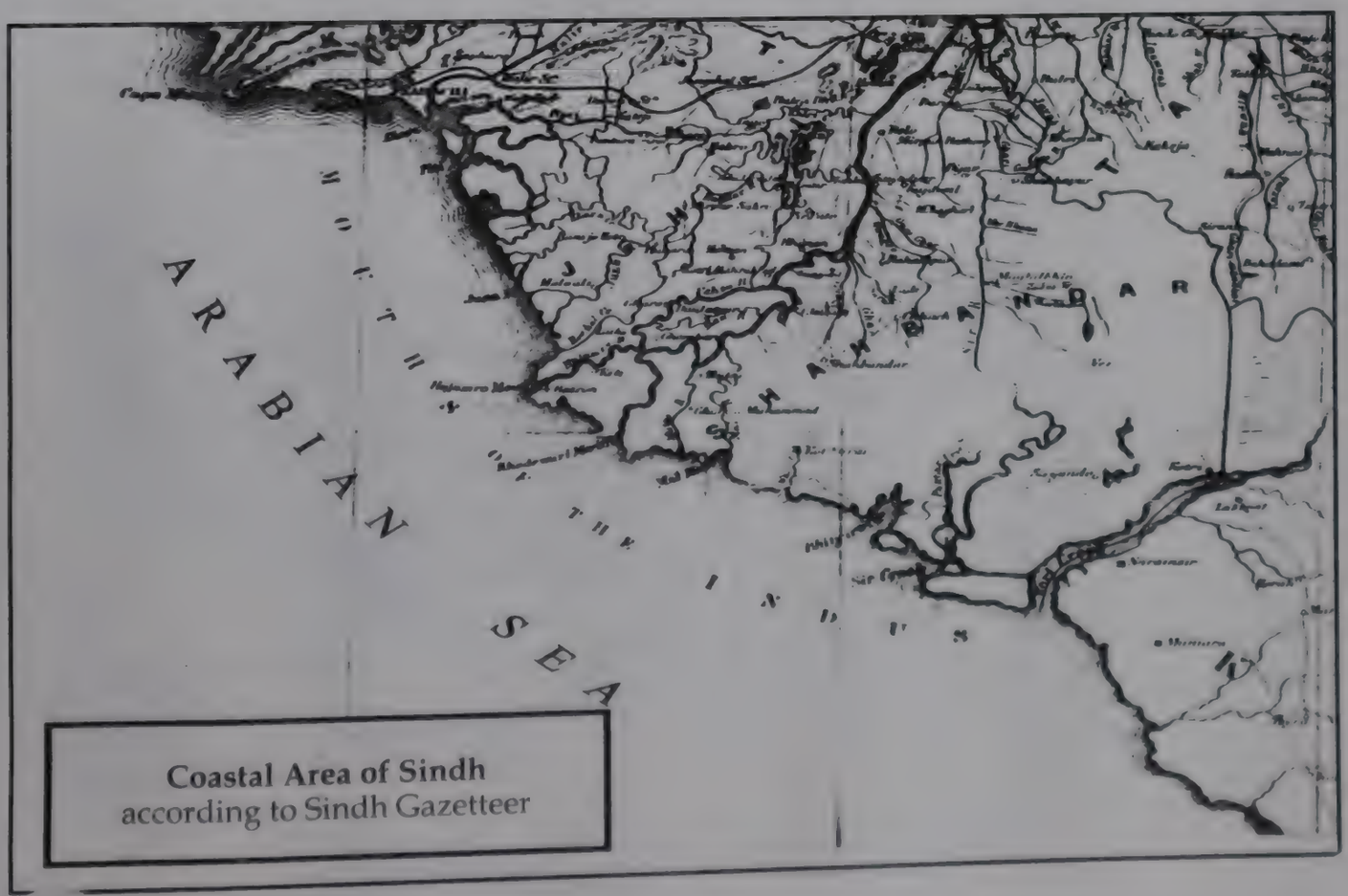
Ancient trade route connecting Amri-Kot-Diji and Summer via Indus Delta and typical craft used in those days (Around 3000 BC).



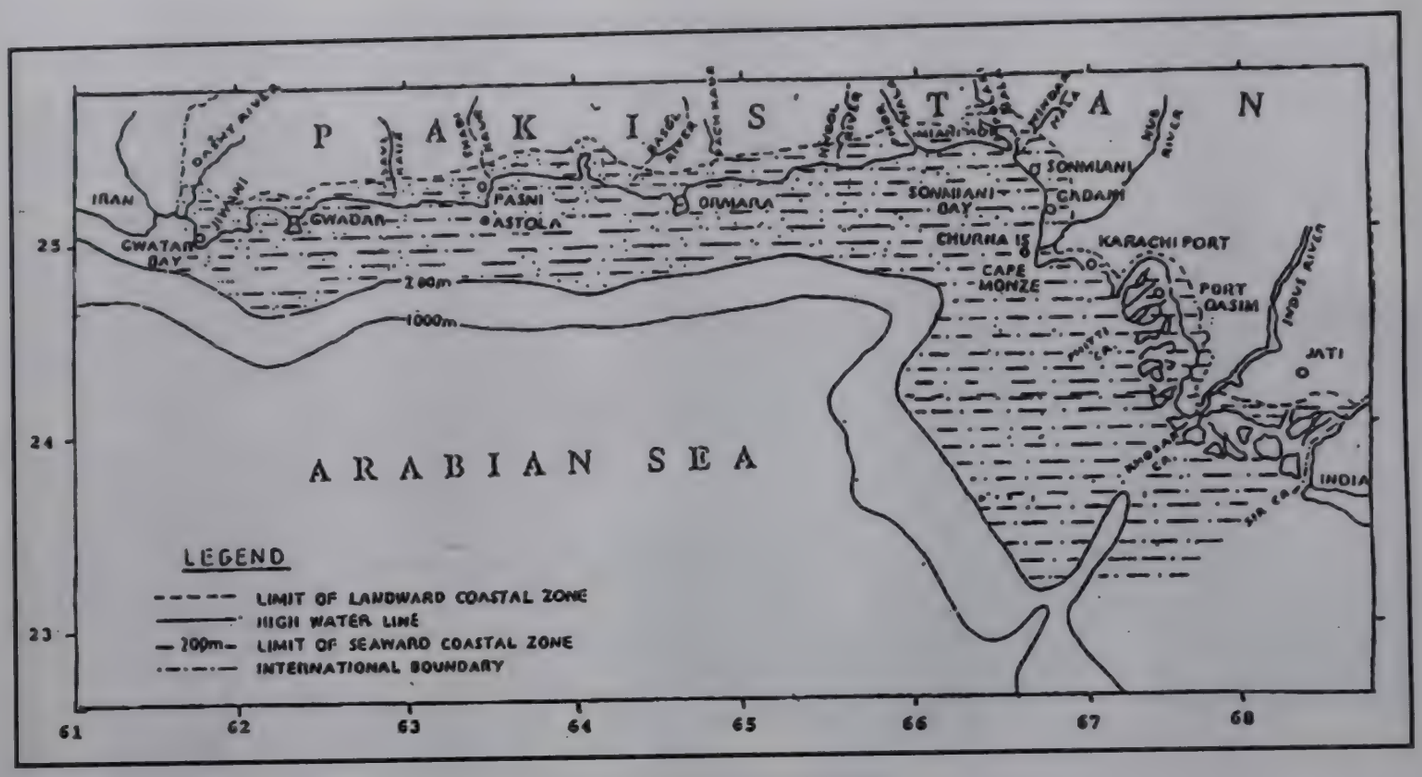
A view of Arabian Sea showing Indus Fan and Murray Ridge



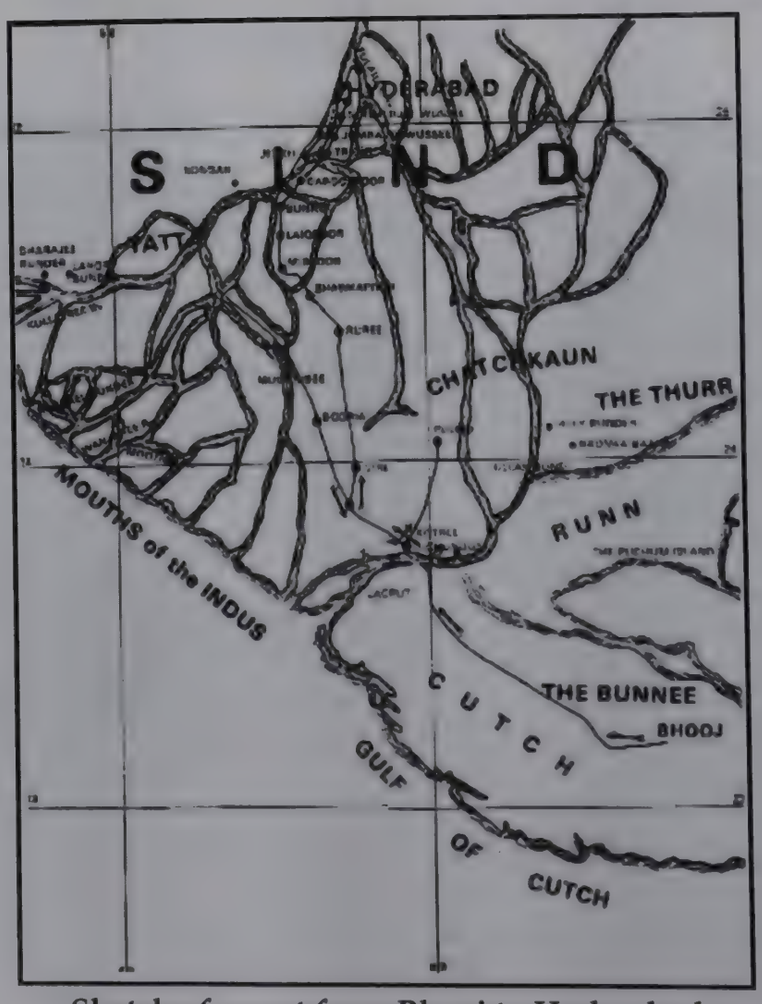
Sindh Coastal Zone



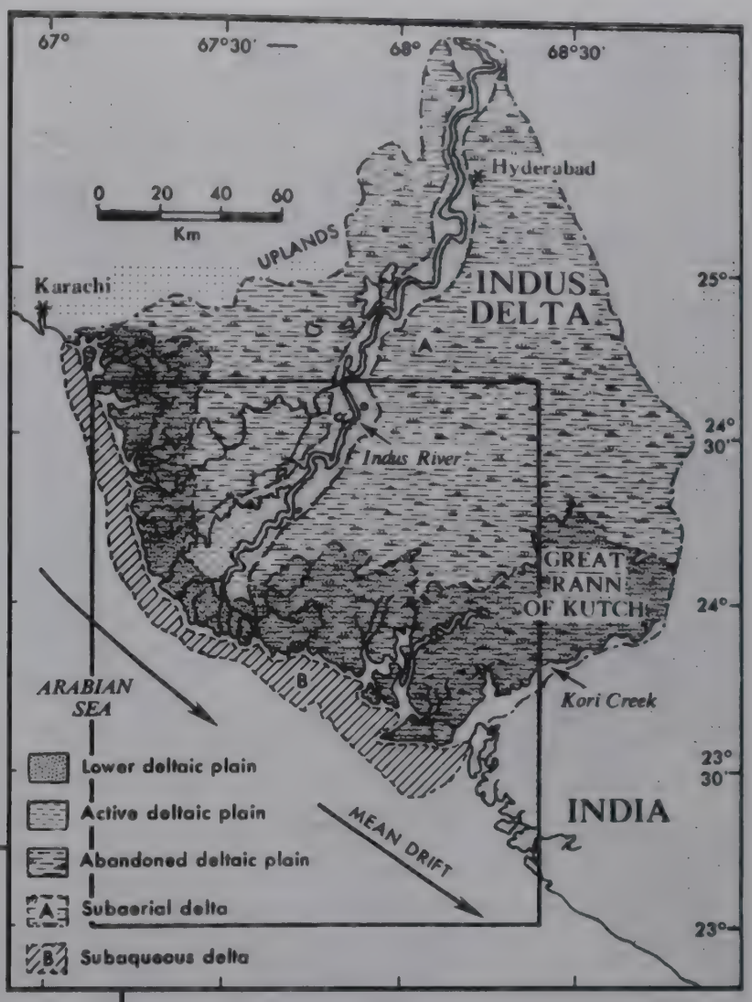
Coastal Area of Sindh
according to Sindh Gazetteer



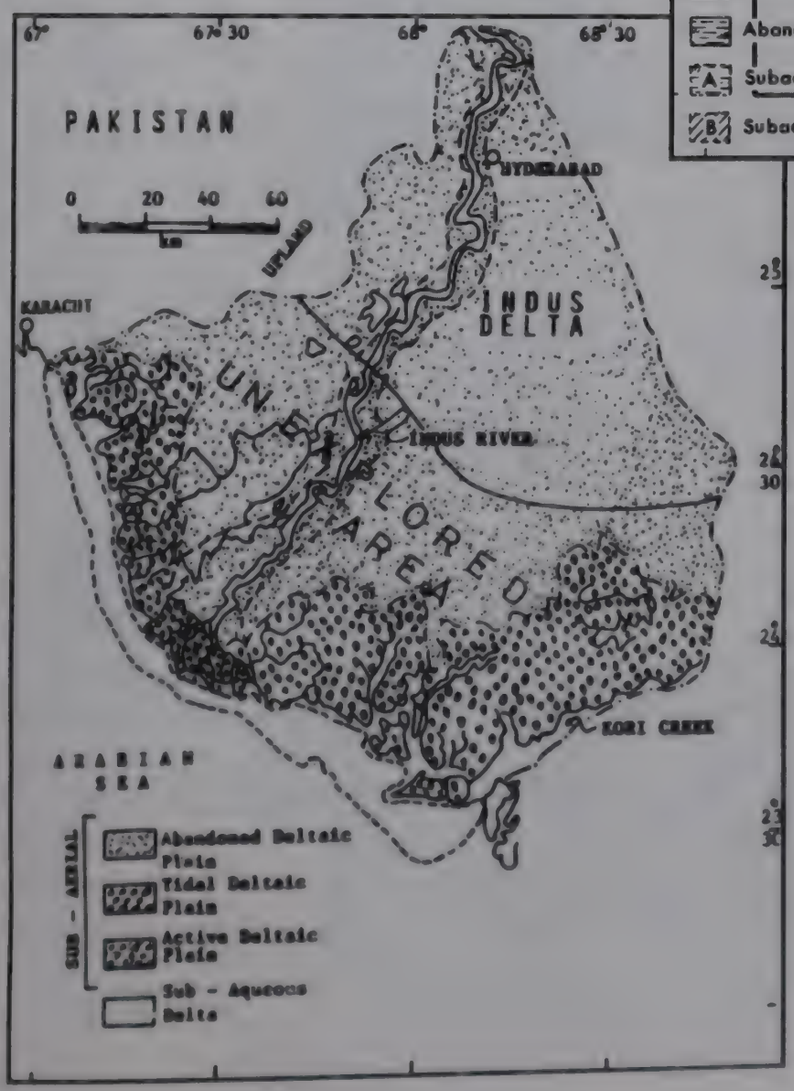
Coastal Zone of Pakistan



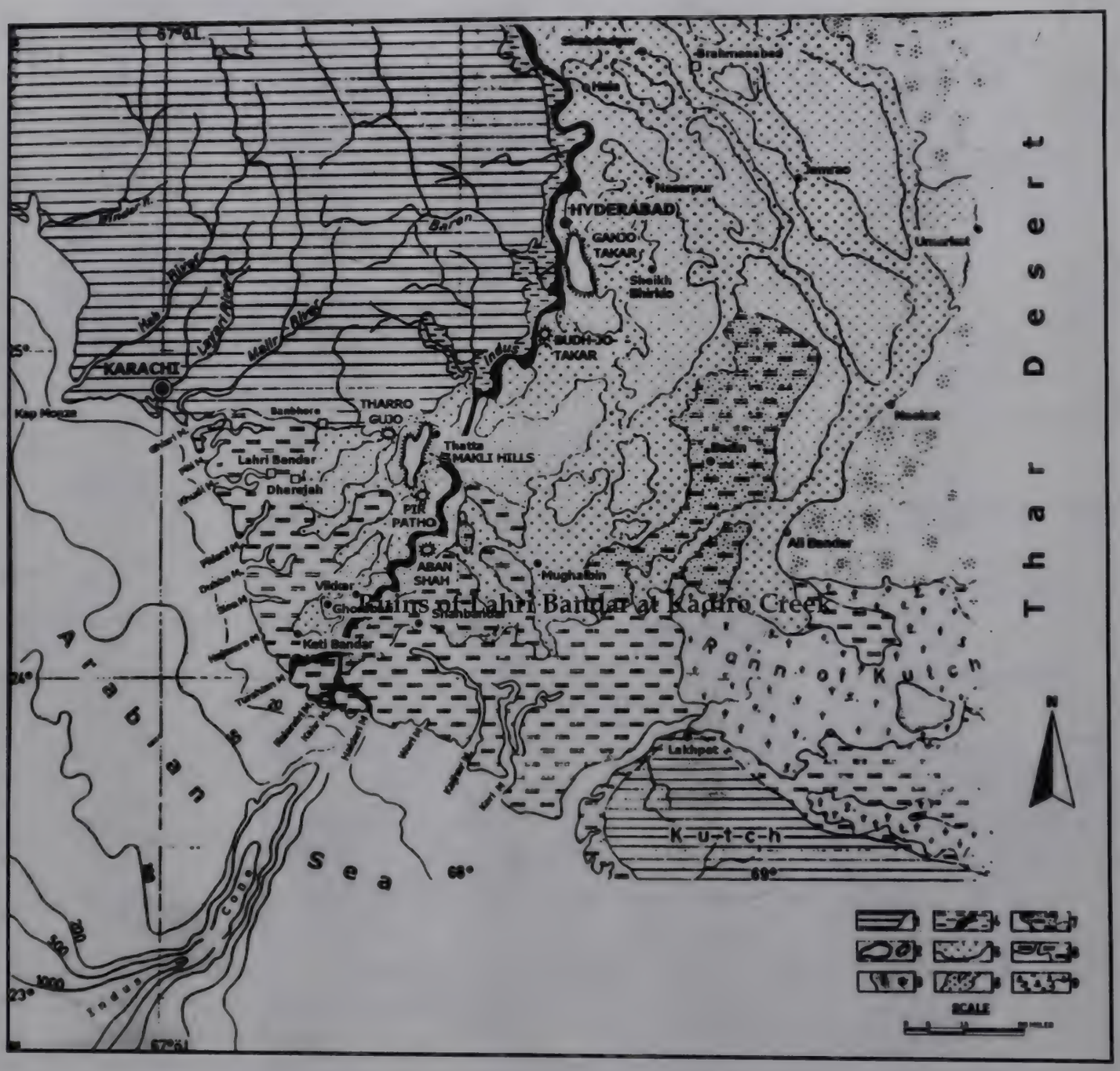
Sketch of a rout from Bhooj to Hyderabad



Map of the Indus River delta in Sindh showing the physiographic subdivision of the deltaic plain



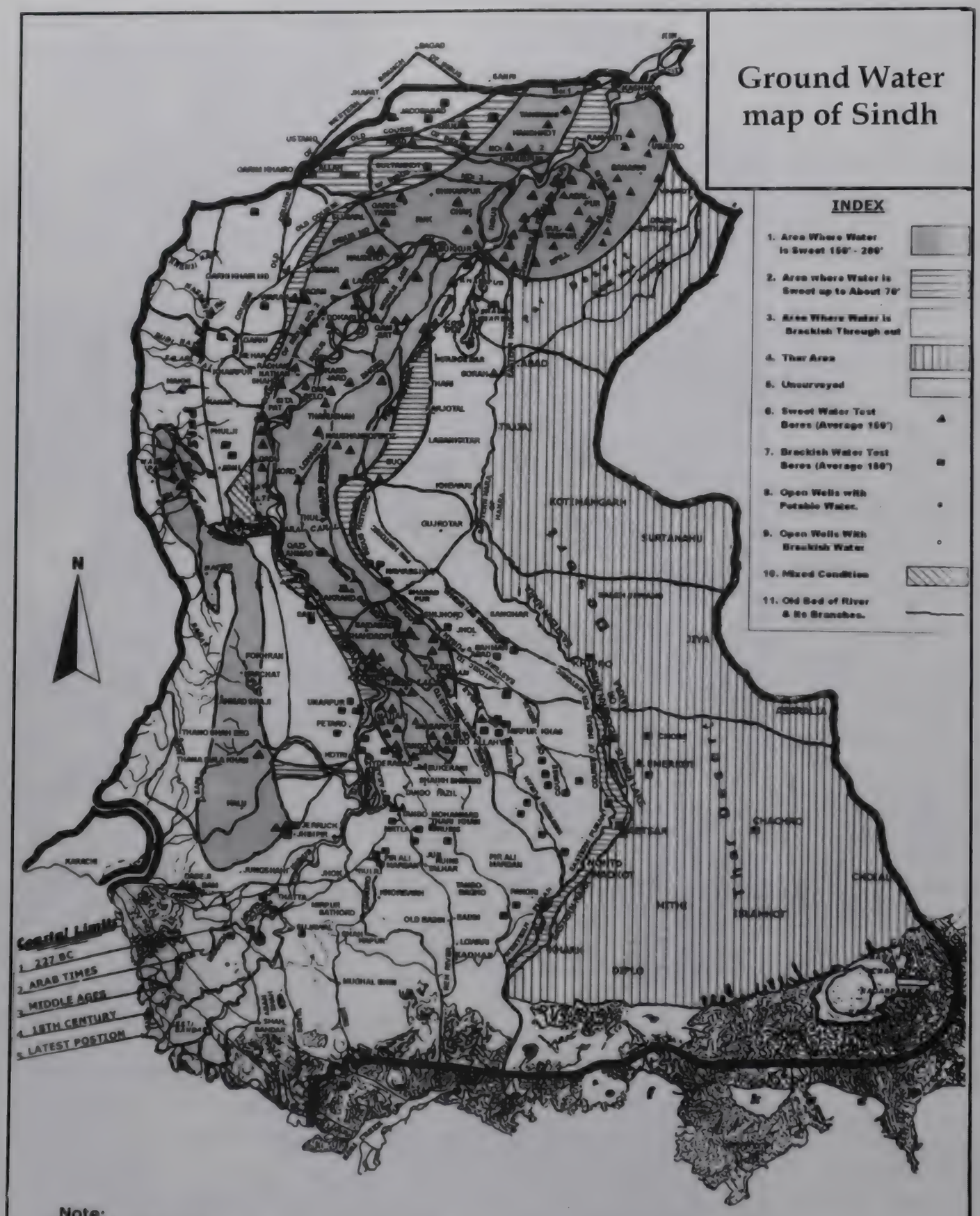
Composite Lithological Logs



Geomorphology of the soil in Southern Sindh, built by the River Indus

part depositing near the coast, but some reaching even 130 kilometers from coast. The sea has depth of 200 meters from Baluchistan coast at only 10 kilometers distance but from Sindh coast it is 130 kilometers inside the sea, i.e., continental shelf is that far. Annual deposit of silt in the sea and sea tides and waves bring it back towards the shore and have advanced sea coast by an average of four kilometers per century. McDonald in 1966 estimated delta a growth of 80 kilometers in 2000 years i.e., 4 kilometers a century and the flood plains of Sindh rise by 9 meters in 5000 years. This is double the estimate of Haig. From the history it has been inferred that sea coast was near Gujo to Talhar in 324 BC.

The Arabian sea Floor showing the relationship of the Carisberg fault escarpment to the Kirthar Range and also the Indus Cone south of the Swatch. Depths inmeters below sea level


Ground Water map of Sindh
INDEX
1. Area Where Water is Sweet 150' - 200'
2. Area where Water is Sweet up to About 70'
3. Area Where Water is Brackish Through out
4. Thar Area
5. Unsurveyed
6. Sweet Water Test Bores (Average 150')
7. Brackish Water Test Bores (Average 150')
8. Open Wells with Potable Water.
9. Open Wells With Brackish Water
10. Mixed Condition
11. Old Bed of River & Its Branches.
N
Coastal Limits
1. 227 BC
2. ARAB TIMES
3. MIDDLE AGES
4. 18TH CENTURY
5. LATEST POSTION
KOTRI
KOTRI BARRAGE
KOTTRI
SURTANGU
JEVA
KHARI
KHARIO
MITHI
DIPLO
KARACHI
THATTA
SAMARO
BADIN
TANDO MUHAMMAD KHAN
TANDO ALLAHYAR
HYDERABAD
NAWABSHAH
SHAHDADPUR
SANGHAR
KHAIRPUR
SUKKUR
JACOBABAD
SHIKARPUR
LARKANA
DADU
JOHI
MEHAR
SEHWAN
MORO
NAUSHERO FEROZ
SAKRAND
MOHAMMAD PUR
KANDIARO
TANDO ADAM
TANDO BAGO
TANDO JAM
TANDO ALLAH YAR
TANDO MUHAMMAD KHAN
TANDO FAZIL
TANDO BAGO

Growth of Delta

It is based on calculations of coastal authorities. In general delta is according to the table below:

Historical Cost Line

Historical Period	Delta	Delta position compared to today
Amri Kot Diji	3000 BC	50-60 miles inland along Gharo-Badin
Alexanders times	325 BC	35-40 miles inland Gujo-Pir Patho - Kadhan
Last days of Brahman Dynasty	700 BC	20 miles inland near Jati
Talpur period	1800 AD	3 miles inland
Opening of Kotri barrage	1955	Current

This is based on scientific calculations that coast advanced by at least 4 kms a century in the 19th century, but coastline was much wider before and therefore coastline has been at Tando Bago around 3000 BC.

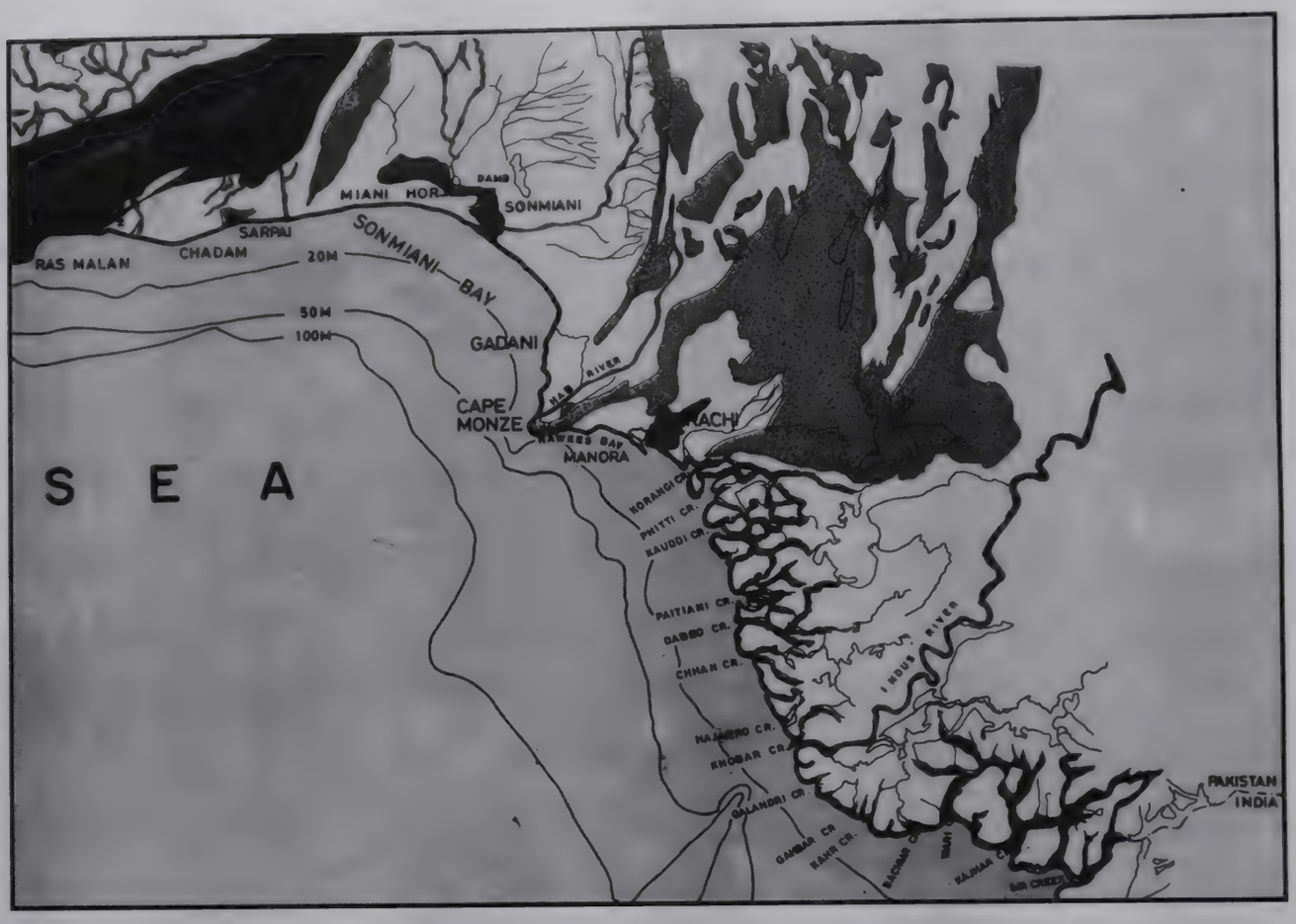
The delta was dynamic and changed continuously developing fan like shape, due to main stream carrying most of silt, but some passing through various estuaries. It was brought back by tide and wave action, both helped by summer monsoons and high wind velocity blowing from south west, during April to September.

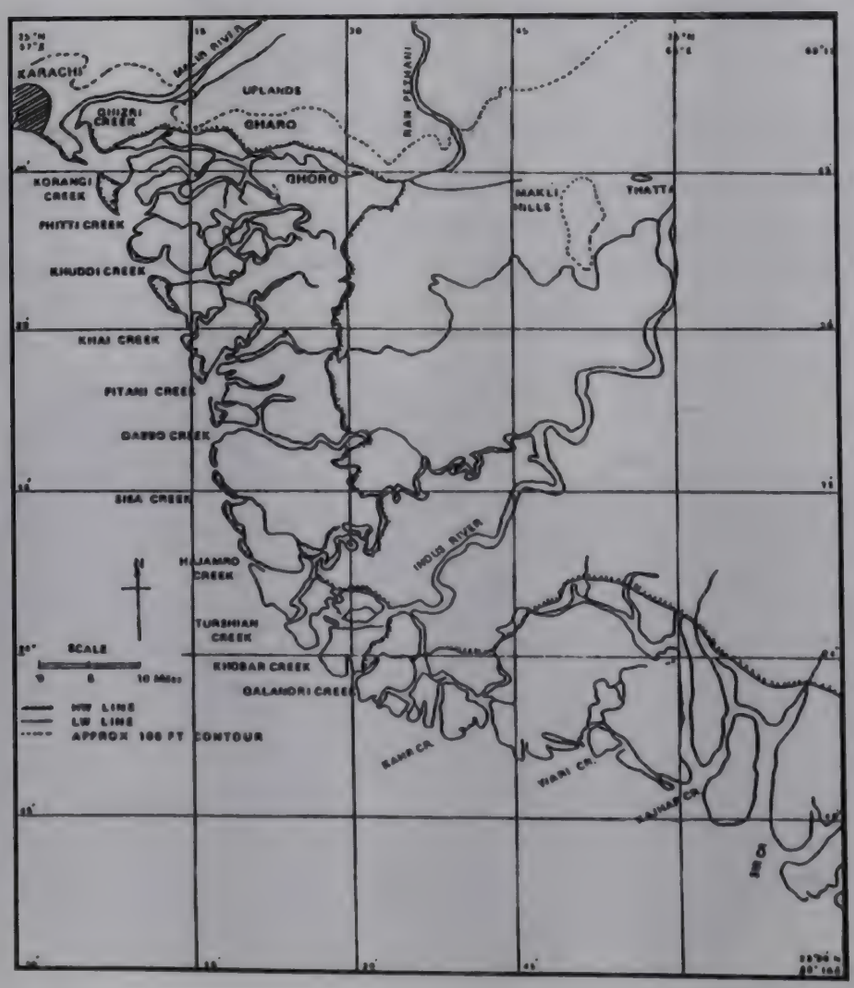
Pakistan coastal statistics and importance

- Pakistan coastline 825 kms.
- Territorial coastal zone 23,820 sq. kms.
- EEZ (Exclusive Economic Zone) 196,600 sq. kms.

Importance of Indus Delta Statistics on coastal area

Length of coastline of Sindh Province is 320 kilometer. Total area of Coastal zone is 35,000 square kilometer. (Including Indus delta of 7000 square kilometers inter tidal zone).


MIANI HOR
DAMB
SONMIANI
SARPAI
CHADAM
RAS MALAN
20M
SONMIANI BAY
50M
100M
GADANI
HAB RIVER
CAPE MONZE
KARACHI
MANORA
SEA
KORANGI CR.
PHITTI CR.
KHUDDI CR.
PAITIANI CR.
DABBO CR.
CHHAN CR.
INDUS RIVER
KHOBAR CR.
GALANDRI CR.
GANGAR CR.
RANN CR.
PAKISTAN
INDIA


KARACHI
MALIR RIVER
UPLANDS
GHIZRI CREEK
GHARO
RANN PEEMARI
KORANGI CREEK
PHITTI CREEK
KHUDDI CREEK
KHAI CREEK
PITANI CREEK
DABBO CREEK
SIRA CREEK
HAJAMRO CREEK
TURSHIAN CREEK
KHOBAR CREEK
GALANDRI CREEK
SCALE
HW LINE
LW LINE
APPROX 100 FT CONTOUR
INDUS RIVER
RANN CR.
PARI CR.
KAJHAR CR.

Land-ward coastal zone is area extending up to 2 kilometer land-ward from High Water mark.

Studies of Costal Areas

AREA	STATISTICS
Karachi coast	
Open sea coastline	60 kms
High water line length	40 kms
Width of coastal zone	.-3 kms.
Indus delta coastline	
Open sea coastline	260 kms
High water line	20 kms.
Width of coastline	5 kms.
Coastal zone are	600 sq.kms.
Types and lengths of physical shoreline	
Rocky shores	0 kms.
Coral reefs	5 sq. kms
Back waters	30 sq. kms
Sand dunes	35 kms
Creeks length	60 kms
Creeks area including flat and mangroves	600 sq. kms
Mud flats with mangroves	0.44 million hectares
Mud flats without mangroves	0.5 million hectares
Creeks (water channels)	16 million hectares
Fish resources	270,000 metric tons
Fin fish landing	120,000 metric tons
Shell fish landing	10,000 metric tons

(a) Measurements of seawater intrusion based on existing and historical data in terms of salinity of water i.e., 37,000-27,000, 27,000-17,000, 17,000-3,000 and < 3,000.

(b) Present position is discussed above.

Aqua culture potential

- Shrimp farming (Extensive) 100,000 - 300,000 tons/year
- Shrimp farming (Intensive) 400,000 - 700,000 tons/year

Mangrove forests

Previously covered area under mangroves 0.44 million hectares and now have Shrunk to 0.12 million hectares, but density has reduced almost to 1/3rd and production to about 10%

Major uses of land-ward coastal zone

The major uses are:

- Fisheries;
- Fire wood;
- Fodder;
- Timber;
- Small scale fisheries in inter-tidal areas aqua-culture in deltaic area;
- Sea salt production;
- Aqua culture in deltaic area (possible);
- Recreational beaches, boating sports, boating, rural housing in coastal belt;
- Urban housing near Karachi.

Major uses of seaward coastal zone

- Fisheries;
- Shipping;
- Recreation (for locals);
- Coastal industries for cooling water;
- Sewage and waste disposal;

Environmental problems

- Seawater encroachment;
- Reduction in fresh water input from the Indus river and maintenance of estuary productivity;
- Human pressure on mangrove forests which are dwindling;
- Environmental degradation of mangrove forests;
- Industrial and municipal wastes;
- Increase of salt in coastal and creek water

Scientific studies of Indus delta and inter provincial agreements

Scientific survey of Indus started in 1831, when as per plans of Lord Ellenborough, who as Chairman of the Board of East India Company had proposed conquest of Sindh in 1830 and with this object first survey of Indus and Sindh was undertaken by Alexander Burnes in the following year and then surveys continued, producing a reasonably good map of Sindh before its conquest in 1843. Since then surveys continued and 1903 Lord Curzon established Indus River Commission, which in next 20 years lead to decision, that no water from the Indus and its tributaries could be diverted without consent of NWFP, Punjab, Baluchistan, Sindh, Bahawalpur and Bikanir. All the present troubles are due to violation of this principle. Since then there have been a number of Commissions and Agreements: Anderson (1934), Rao (1945), 1970 and 1991. All of them have been violated.

Tidal zone statistics

- The river below Kotri discharge is now reduced to $1/5^{th}$
- Present deltaic area is 100 sq. miles against the past deltaic area in 1950s was 1,000 square miles;

- Tide range is 2.6 m but in monsoon months more than 3.0m;
- Tide wave energy is 14x107 erg/sec;
- Mangroves are desiccated by monsoon winds and tidal waves;
- The previous delta was river dominated and the present delta is wave dominated;
- The results of this at present is that extreme level of wave energy and storm eddies have resulted into rapid wave re-working and transgression of the Indus delta. The lower deltaic plain has been affected by salt water intrusion and salinity. Keti Bander having population of 25,000 souls is now reduced to 5,000 persons and all villages around it have been submerged, but others away from it have been either depopulated totally or have reduced to less than 10%.

Subaerial delta of Indus

Sub-aerial delta of the Indus is second largest in the world only slightly smaller than Hwangho. Its sub-aerial delta is larger than Volga, Mississippi, Niger, Nile etc. This is due to south west winds which deposit back the silt in the Indus and shore line, forming dunes which in turn rose above the river and the sea. Another factor is low tidal range. In case of Ordict is 5.8 meters, Amazon 5 meters, Yangtzekkiang 3.7 meters Ganga 3.6 meters and Indus 2.6 meters though in monsoon season it exceeds 3.0 meters.

Status of Indus delta compared to other deltas of the World

Neither Indus is the biggest river in terms of its discharge, nor is its delta is so big. The Indus delta is ranked as # 7 in area of its size and from highest to lowest:
1. Amazon 2. Ganga 3. Mekong 4. Yantzekiang 5. Lena 6. Hwan Ho **7. Indus** 8. Mississipi 9. Volga 10. Irrawadi 11. Orinaco 12. Niger 13. Shattar Al Arab (Euphrates) 14. Grijalva 15. PO 16. Nile 17. Chao Phraya 18. Mackenzie 19. Gadavari 20. Seneg.

Month wise percentage of salinity in Indus delta in a year
Table below gives percentage density of sea water at 3 places along the coast

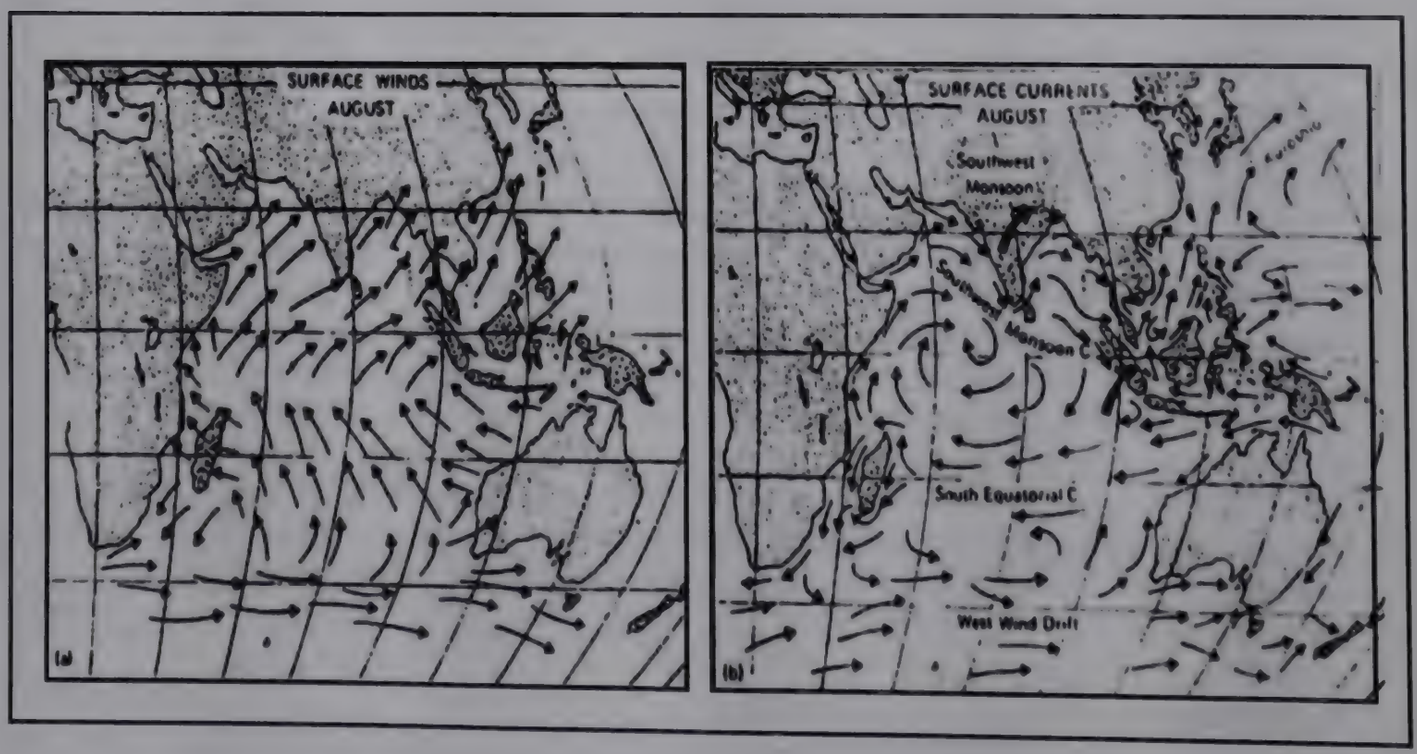
Month	Korangi Creek	Keti Bunder	Shah Bunder
January	3.8	3.1	3.1
February	3.8	3.1	3.1
March	3.7	3.0	3.1
April	3.7	2.5	2.5
May	3.5	0.4	0.4
June	3.5	0.4	0.4
July	3.3	0.1	0.1
August	3.5	0.1	0.1
September	3.5	0.1	0.2
October	3.8	2.8	2.9
November	4.1	3.3	3.2
December	4.2	3.8	3.8

The above table leads to interesting conclusion

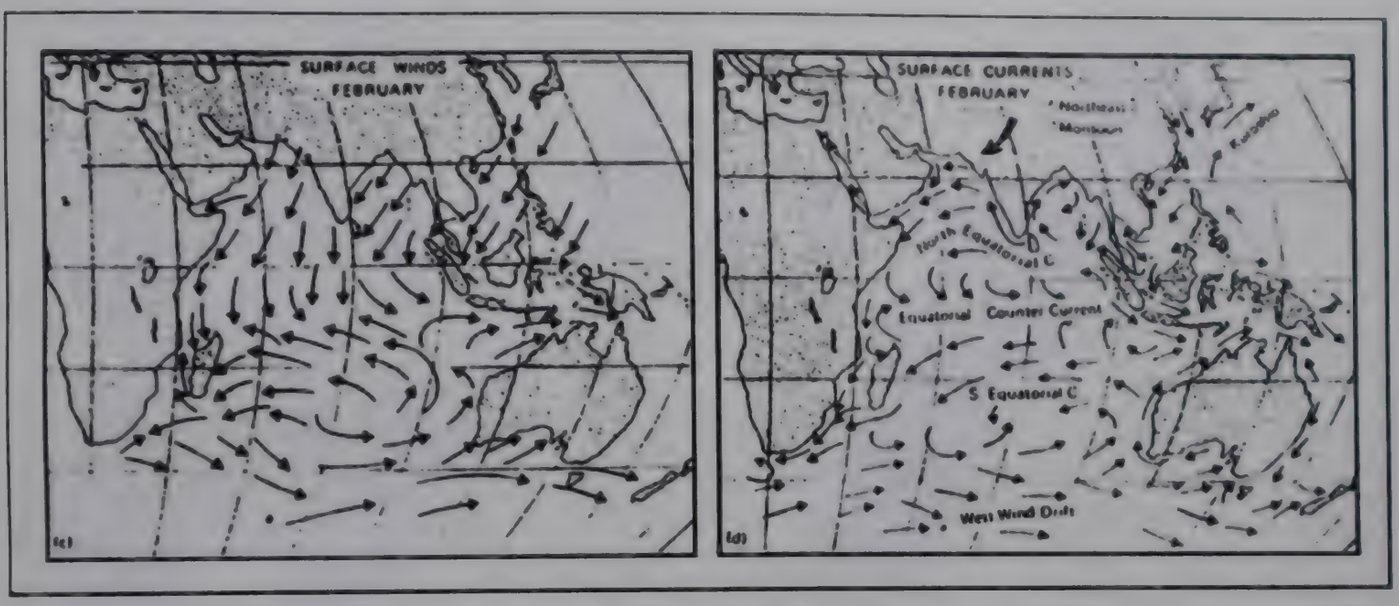
- Salinity of seawater near the mouth of the river close to Keti Bander and Shah Bander becomes low as river discharge in July-August dilutes seawater, but effect is not perceivable near Karachi as Indus waters do not reach Korangi and Liari creeks.
- After September salinity in the creeks rises reaching maximum in December. Due to Kotri barrage closure around December 21, about 1MAF water stored in the pond of the barrage is released to the sea and salinity drops from 3.8% to 3.1% at Keti Bander and Shah Bander. Salinity again fell down at these two places in May and June due to Indus discharging flood waters into the sea.
- Effect of fresh water discharge by the Indus River in the sea is perceived at Korangi with sufficient time, lag and salinity is reduced only a little. If discharge is more and for longer time effect with spread all along the coast.
- In December salinity reaches its maximum at Korangi, Keti bander and Shah Bander, respectively being 4.2, 3.8, 3.8% and higher than Arabian Sea, which has salinity of 3.6%.
- It is also disturbing that high salinity can cause damage to mangroves and habitat of many fauna, especially crustacean fishes etc.
- Sudden drop in salinity in April, May and June is connected with unusual high rains in the northern areas during the year, but normally salinity remain high until July.

Eddies and direction of water movement in Arabian sea at depth of 15m, 200 m and 500m.

It can be seen that the currents move clockwise in July due to south-west monsoons and anti clockwise in January due to north east Monsoons. In fact it is May to September and October to March.



Surface winds (a) and Monsoon currents (b) in summer during the Southwest Monsoon



Surface winds (c) and Monsoon currents
(d) in winter during the Northeast Monsoon

Estuaries and brackish water

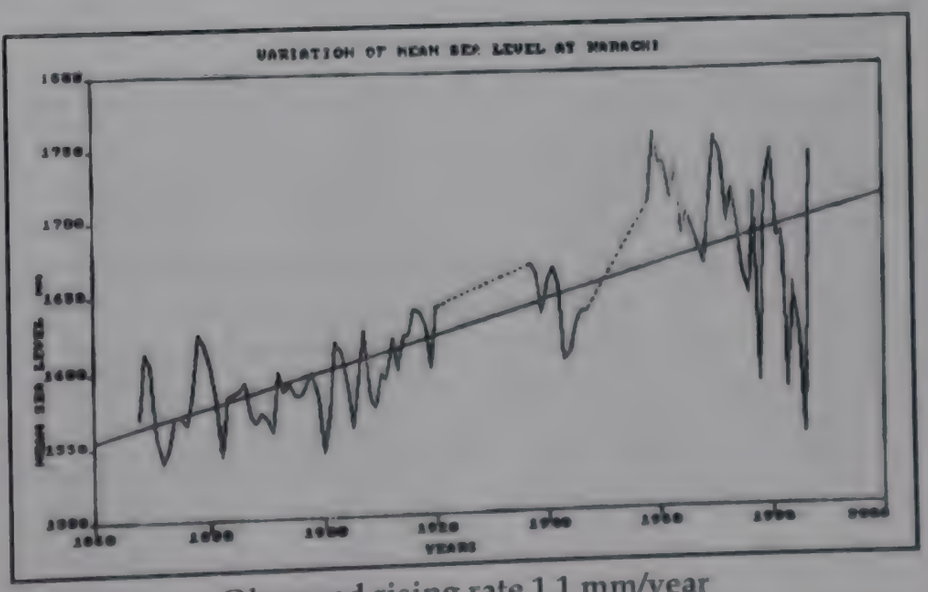
- Estuaries which discharge river water directly have low salinities and extent of low salinity zone depends upon volume of discharge of river into the sea;
- Lakes which receive water from the river Indus, but have permanent connection with the sea exhibit salinity gradient from seawater to nearly fresh water;
- Lagoons or back waters close to shore, when flooded by the Indus get connected with the sea to discharge their waters, but get cut off after inundation and usually have fresh water and are included in wet lands.

Salt marshes of Pakistan

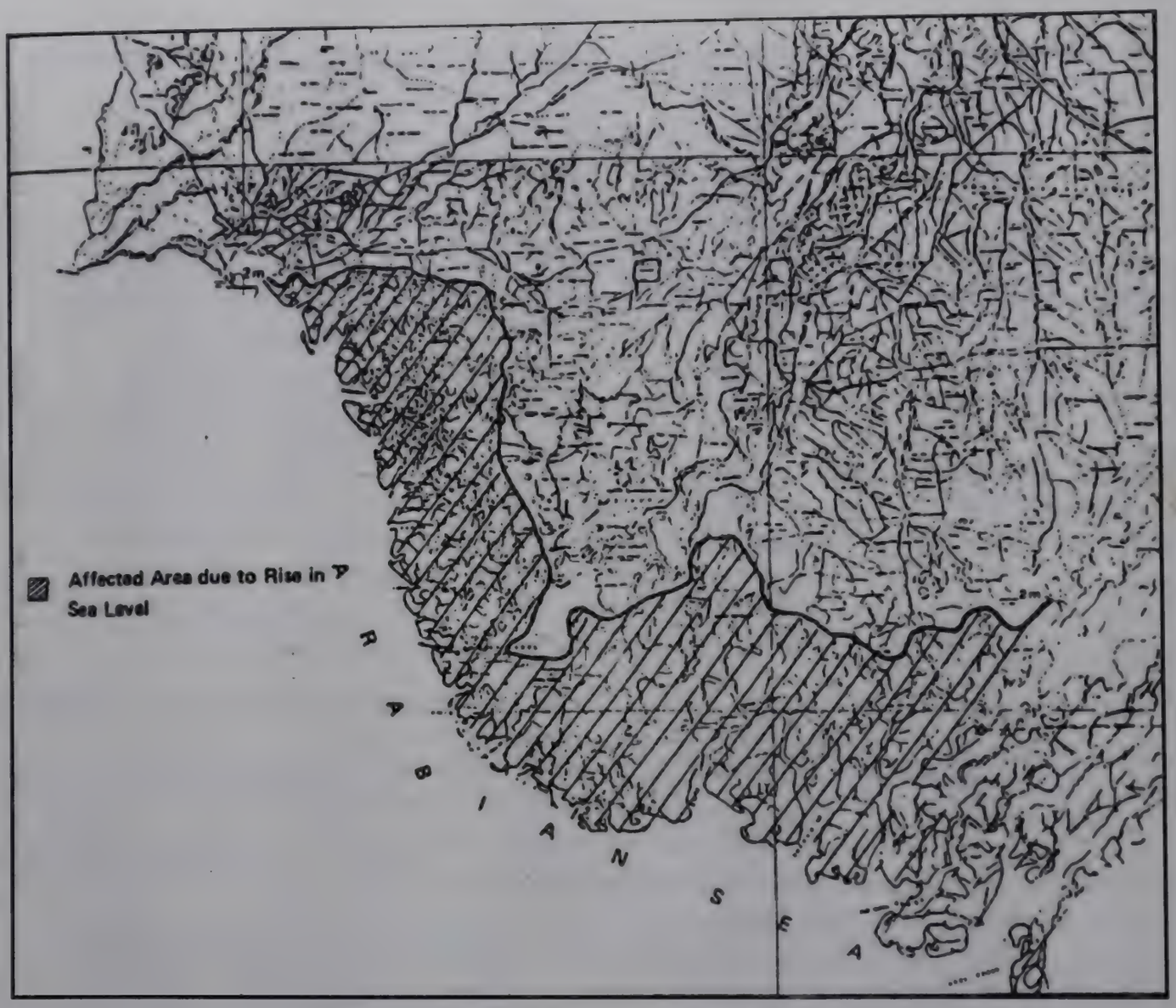
The lakes connected with sea only in certain period evaporate and salt content in those rises above that of sea meaning some species survive in them due to natural adaptations.

Sea level rise

Sea level has been rising since end of Little Ice Age (1350-1850 AD in Sindh) at the rate of 1.1 mm per year due to warming, since 1850 already rose by 165 mm (6.5 inches). The temperatures are still rising and glaciers are melting. Sea level is at least 2 meters higher in Sindh now than was at that time of Alexander's conquest in 325 BC and will probably rise further and quickly in the next decade.



Observed rising rate 1.1 mm/year



Indus Deltaic area affected by sea-level rise

Threats to coastal and estuarine wetlands

Coastal wetlands serve as buffer between shore and densely populated towns and agricultural areas, against high tides and storms etc. Mangroves are very important component of this environment and plays role of building up and extending coastal soil through accumulation of coastal sediment and protecting shoreline. The wetlands conserve wild life.

The Major threats are pollution and over exploitation. In recent years the Indus River and its tributaries carry heavy loads of urban, industrial and agricultural effluents into coastal and estuarine wetlands, disturbing the ecological balance. As there has been total lack of understanding and negligence of these problems, it is feared that these resources can lost for ever, unless immediate attention of all stakeholders and Federal Government is drawn towards this issue. These are further discussed in next chapter on Arabian Sea.

Chapter 4

ARABIAN SEA

Sources of pollution in Arabian Sea

a) Oil pollution at ports, bays, creeks, thorough tankers, cargo vessels and passenger ship leaks and vessel discharges which include unloading of oil at harbors, pipe leaks, trawlers and engine of ships;
b) Industrial pollution, form 4000 acres of Sindh Industrial Trading Estate, having 300 major and 900 minor industries, of them textile is largest. The other which produce pollution are: batteries, cement, chemicals, electroplating, electric power plants, food and beverages, tanneries, oil refineries, paints, dyes, paper, pesticides, pharmaceuticals, plastics, rubber, tobacco, vegetable and heavy engineering works;
c) The same is effect of Landhi-Korangi industrial areas as shown in (b) above.

Marine pollutants

Sources of major pollutants of sea - via Malir riverbed through Korangi creek and via Liari River and industries are listed in table below:

Sources of pollution in sea through Malir and Liari rivers

S. No.	Industry	Major Pollutants
1.	Textile industries	Metal oxides, coloring compounds wood and cotton fibers
2.	Tanneries	Chrome salts, organometallic compounds, high BOD organic wastes
3.	Pharmaceutical industries	A variety of inorganic/organic compounds and toxic substances
4.	Plastic and rubber industries	Polyvinyl chlorides, polyethylene polypropylene, polyesters, etc.
5.	Steel foundries and metallurgical industries	Cooling oils, PCBs, acids and alkaline deoxidizing agents and metal salts
6.	Electroplating of surface coating industries	Heavy metals, metal oxides, metal sulphides and polyhydroxy phenols
7.	Glass, Ceramics and tiles industries	Metal oxides, CO
8.	Soap and detergents	Fatty acids, glycerin, oils
9.	Fish processing industries	High BOD organic wastes
10.	Chemical industries	Various organic and inorganic compounds
11.	Fertilizers and pesticides	Inorganic compounds pesticides and insecticides
12.	Power stations	Chlorine, heavy metals, lubricating oil, metal oxides and sulphur compounds

Karachi City pollution

Karachi the foremost and coastal city of Pakistan has contributed the following to pollution of sea:

Major sources of pollution is sea from Karachi city

Water use:	50000 million gallons per day
Sewerage discharge:	12260 million gallons per day
Solid waste:	30,000-5,0000 tones of solid waste per day
Untreated waste entering sea through Malir, Liari and other creeks:	70% of all untreated waste water
Industrial area of west Karachi and Landhi-Korangi producing textiles, heavy machinery, beverages, automobiles, silk, oil, soap, food stuffs, chemicals pharmaceuticals, steel, glass, cigarettes, paints, filament yarn, and ready made garments:	Above described industrial areas 6,500 acres and consuming 4,922,500 liters of water a day
Karachi harbor oil products imported and some oil spills:	200,000 tons a year

Threats to Area

The area is threatened by many different agents namely, chemical, biological and physical and are listed below:

Chemicals threats

These are mainly sewage, agriculture and urban chemicals namely:
Fertilizers, pesticides, herbicides, heavy metals from industrial waste, pathogens, chlorinated hydrocarbon, sewage, phosphates, and warm or cold water from industrial waste.

Biological threats

They are in form of removal of some useful species through non selective fishing.

Physical threats

These are human activities of setting up roads, industries, harbors, over grazing, dams, drainage and wood removal - all beyond limit of replacement.

The Arabian Sea potential for minerals and hydrocarbons

- North Arabian Sea has potential for oil, gas, minerals, proteins, vitamins, renewable energy etc.
- It is one of the most productive area of the World with unique geodynamic history:

Productivity of World oceans

Productivity of world oceans in terms of gram carbon, per square meter per day is given in table below:

Productivityof various oceans/seas

S. No.	Sea or Ocean	Productivity gram/c/sq.m/day
1.	Gulf of Oman	5.7 - 6.4
2.	Arabian sea	1.5 - 1.8
3.	Weddell sea	1.56
4.	North Sargasso sea	0.214
5.	Antarctic ocean water	0.89
6.	Indian ocean	0.71
7.	Pacific ocean	0.52
8	Atlantic ocean	0.41

This shows that baring Gulf of Oman, Arabian Sea has highest productivity in the world.

- Arabian plates are not more than 70 million years old, while South Asia is probably at least 4.6 billion years old and Gandawaland hills at Nagar Parker at least 600 millions years old.
- The seawards coastline of the Indus is 80-100 nautical miles (92-115 miles or 149-187 km) wide sloping with gentle gradient of 0.022.
- It has a large relief of 3.5 km depth with deep water circulation.
- Government of Pakistan has declared its marine rights in Gazette of Pakistan. Pakistan Territorial rights extend to 12 nautical miles and EEZ extends to 200 nautical miles. Pakistan has sovereign rights in EEZ area for exploring, exploiting, conserving, managing living and non living resources, under water, in the seabed or beneath the submarine soil and also extracting energy from currents, wind waves, tides etc.
- Potential of EEZ (Exclusive Economic Zone) is 1,500,000 metric tons of living resources, in addition to 10 million metric tons of mesopelagic fishes.
- Continental margin lies 350 nautical miles from the coast.

Ecology of Northern Arabian Sea

- Rich fisheries North Arabian are connected with high chlorophyll and plankton in the region due to nutrients of the (phosphates and nitrates) and solar light falling on the sea surface.
- Nutrients also come from flow of fresh water from the Indus, causing up-wheeling process from sub-surface level.
- High concentration of nutrients in deeper water is attributed to release of nutrient from decomposition of organic matter below euphoric zone. The up-wheeling process brings these nutrients to the surface.
- North Arabian Sea has up-wheeling areas along the coast as well as off shore areas.
- By above process nutrient rich in waters are brought within the depth of solar light penetration.
- North Arabian Sea has strong thermal stratification near the surface in upper 200 meters helping in productivity.
- Oxygen content in Northern Arabian Sea drops sharply below the surface. On many occasions the oxygen minimum occurs below depth of 50m and high oxygen layer is confined near the surface, due to high organic production in the euphotic zone and strong wave action.

- High levels of oxygen and nutrients near the surface are conductive to high biological productivity.
- Strong monsoon winds modify water mass near the surface and induce changes in mixed layer isothermal layer near the surface and affect sea surface temperatures. Monsoons also create divergence and convergence of water mass in the centre of Arabian Sea.
- Persian Gulf water entering into Arabian Sea from North West with high temperature and high nutrients (of Gulf of Oman) mixes with nutrient of Indus water. Thus making north Arabia Sea highly productive.
- All above factors influence primary productivity by creating fertile areas in the up-wheeling zone off the Arabian Peninsula.
- Primary productivity is measured as grams/C/m^2/day, indicating quantity of photosynthesis or phytoplankton and is 1.5 - 1.8, for the almost highest all World's oceans except Gulf of Oman, which also discharge into it, due to higher salt content and higher temperatures.
- The fish biomass of Pakistan is theoretically estimated as 30 million tons.
- Pakistan's fish, 30% is Pelagic and 70% is demersal. It does have mesoplagic fish which is estimated as 20 million tons in north Arabian Sea. In Pakistan waters it is estimated as 10 million tons.
- The potential is going to decrease considerably unless river water is allowed to flow into the sea year around as per various agreements.

Importance of Sea

Surface waters of the World cover area of 361 million square kilometers compared to 50 million square kilometers total surface area of earth. The oceans occupy 71% of surface of earth.
Continental shelves are shallow platforms adjacent to land masses, usually an irregular topography comprising of banks, basins and valleys, but Indus delta like some river delta, usually has smooth floors with clear depression showing points of discharge of old river channels. The seaward limit is shelf break, distinct gradient change from shelf to steeper continental slope, with water depths within range of 35 to 250 m. Continental slope gradients range form 1:3 to 1:40 for major deltas including the Indus.

Various chemical elements in seawater

Seawater has over 99.5% salts in form of chloride, sulphate, bromide, bicarbonate, sodium, potassium, calcium and magnesium. The remainder 0.5% consists of very small amounts of nutrients like phosphate silicate and nitrogen compounds and micro-elements. In addition salts are washed from the earth by the rivers into the sea. Atmospheric dust containing salts is washed down to the sea by precipitation.
Salinity of seawater is reduced by river water, rainfall and melting of icebergs and glaciers of cold countries. Sea creatures extract calcium from seawater and dilute it, but evaporation increases salinity.
Most common elements in seawater are sodium and chlorine forming a little more than 85% by weight. In all there are eighty elements in seawater, but except above the rest are in traces.

Plankton

Biological economy of oceans like that of land is based almost entirely on photosynthesis. Being

dependent on sunlight Primary productivity of sea is restricted near the surface layer, the epileptic or euphotic zone. The depth of this surface layer varies to no more than 30-40 meter and in some cases only a few centimeters.

Phytoplankton

These are microscopic algae which float free in surface layers of water. The productivity depends on temperatures of waters solar light and nutrients in water. Primary productivity of the Indus coast was high due to nutrients brought by the Indus, water was warm and sunlight was plenty due to low cloud cover. This advantage is now lost due to lack of fresh Indus waters containing silt rich in nutrients and productivity is falling down. Phytoplankton is naturally produced material in food chain of all sea animals. It is now much reduced.

Zooplankton

The Zooplankton contains representatives of all main groups of animals from protozoa to larval fishes and sizes from larval fishes to jetty fishes. They become food for some sea animals, which in turn become food for others.

Benthos

They are marine animals and plants which live on or close to sea bottom. Their productivity is greater in shallower near shore regions and on shelf areas of north Arabian seas. Their mean value is: 10-50g/C/m^2. They are suspensions feeders such as polychrretes [serpuriane arthropodal, amphipids, isisphods, decapods, cerripetes and echinodems] are also found.
They are communities closely associated with sea floor. In shallow sea such as Indus delta benthos are supplied with abandoned food and is correspondingly rich due to large supply of planktons.

Fishes

They occupy all level of sea right-up to 8300 meters depth. About 58% of fish species are marine and 13% occupy deep oceans. Color is important for safety reasons. Semi transport fishes occupy shallower depths and overlie dark backed fish with silvery sides.
Below 500 metres depth predominant color of sea animals is black.

Arabian Seawater circulation and productivity

Arabian Sea in its water circulation process has direct impact on economy of all countries around it. Seasonal changes are brought by monsoon phenomena, together with discharge of rivers into its coastal areas. The south west monsoons, which vary from year to year, directly influence economy of coastal areas of Pakistan, as it has been observed from the past two centuries.
Sea surface change has profound influence on the migration of many fish fauna from one place to the other affecting the economy. High resolution infrared radio meter shows warm and cold eddy currents of Arabian Sea and their intensity increases with south west (SW) monsoons from May to September along the Sindh coast. During this period sea up-welling along Arabian coast and cold water plume and wedge extends to eastwards. Eddies also cause vertical and horizontal mixing of water. Physical characteristics of Arabian Sea is changed by out flow of Red Sea and Persian Gulf waters into Arabian sea, through narrow passage near Aden and strait near Bahrain. Red sea salt contents are more than 40,000 ppm and of Persian Gulf more than 35,000 ppm of the Arabian Sea.

12-596

Changes brought by surplus Indus water flowing to the sea in some years and heavy monsoons of 60 inches (152.4 cms) along Karomandal coast. Most of the runoff of monsoon rains of this coast after meeting local needs also discharges into the Arabian Sea.

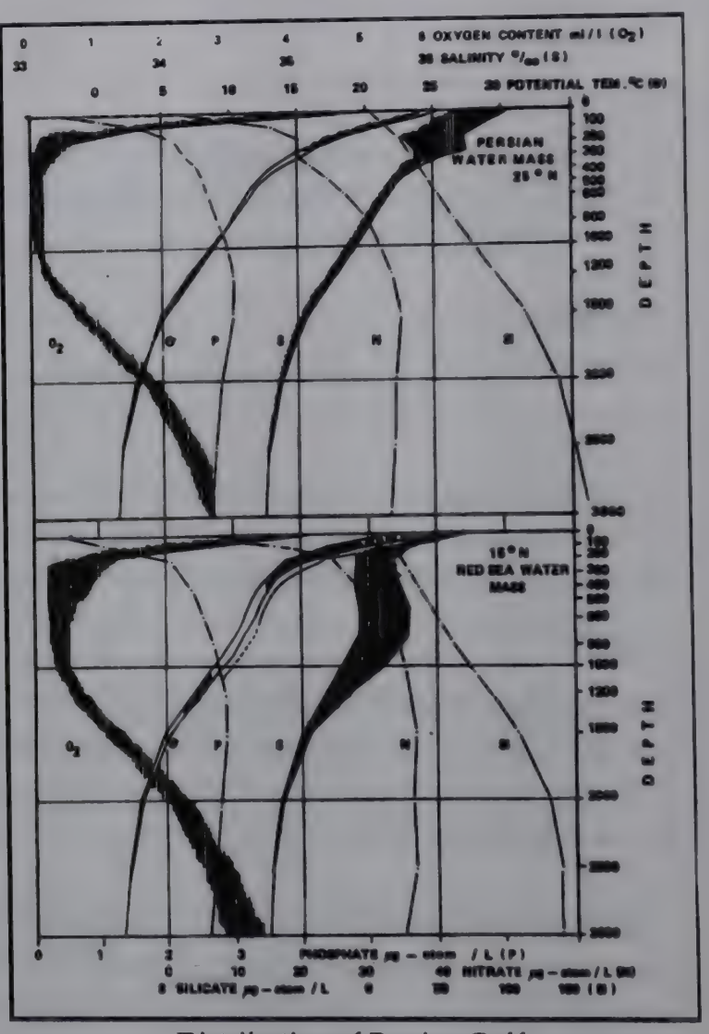
South west monsoons produce positive stress with strong gradients almost covering the whole north Arabian Sea up to 70 E. The area from Somali coast to coasts of India and Pakistan in North Arabian Sea covers some 4,000 kilometers.

The dynamic height and the Indus discharge have a time lag of two months and monsoon intensity can be predicted two months in advance without depending on El Nino movements in the Pacific Sea west of Peru and Chile, where high pressures occur and winds move to low pressure areas of Indian Ocean, of which Arabian Sea is a part.

Monsoons and Thermal structure

There is close relationship between monsoon activity and thermal structure of Arabian Sea. The out-flow of Red Sea at about 750 meters depth and Persian Gulf at about 250 meters depth and again discharge of the Indus high floods as in year 1967, 1973, 1976, 1978, 1983, 1995 and 2006 are reasonably co-related to deeper depth of 20°C i.e., 180-200 meters depth.

Drawing from Satelite Imagery



Distribution of Persian Gulf and Red Sea water in the Arabian Sea

Monsoons and Eddy Circulation

Consequences of eddy currents are that cool temperature of 20°C prevails near the coast and water of 29°C is trapped in the centre of eddy current. Then 20°C isotherms lower to a depth of about 230 meters causing eddy circulation and mixing of waters.

Eddy currents and productivity

Eddy currents help in productivity due to high value of phosphates and nitrates at its core. The mixing of the nutrients from adjoining cool up-wheeled water is clear from depths of 50-500 meters. Even at surface of sea high phosphate concentrations of 2.23 ug-at $P.1^{-1}$ have been observed at the surface.

Eddy circulation improves oxygen content of water, for example dissolved oxygen in water decreases at 26-27°C as compared to that at 20°C or at higher temperatures. Oxygen demand exceeds that of supply at 100 meter depth. Oxygen content of 3ml l^{-1} at 100 meters depth indicate that eddy field is well supplied with oxygen even at 26-27°C. Oxygen content at 3.5 ml l^{-1} shows productivity improvements by eddies.

Distribution of the depth of 20°C isotherm in the Central North Arabian Sea and the Monsoon and River Indus discharge in August in the sea

Depth of 20° C isotherm and Indus discharge

Year	Depth of 20°C Isotherm (May) (Meters)	Location (Latitude and Longitude)	Indus discharge in August (Km^3)
1962	-	-	17.3
1963	-	-	18.9
1964	-	-	25.3
1965	-	-	17.3
1966	-	-	30.3
1967	210	22°N, 61°E	36.2
1968	-	-	27.7
1969	-	-	23.4
1970	-	-	9.2
1971	-	-	12.4
1972	-	-	7.6
1973	170	20°N,10°E	39.1
1974	-	-	3.3
1975	-	-	21.4
1976	200	8°N,9°E 50°N,60°E	38.1
1977	150	16°N,18°E 50°N,60°E	18.2
1978	200	8°N,9°E 50°N,60°E	46.4
1979	200	19°N,20°E 50°N,60°E	16.4
1980	-	-	11.4
1981	-	-	17.9
1982	-	-	6.9
1983	180	21°N,22°E 62°E	26.6

Productivity of Arabian Sea

- Arabian sea with its geographical location, contribution of water, by its rivers monsoon patterns of all countries around it, and mixing of waters from Red Sea, Persian Gulf and Indian ocean, combined with eddies caused by monsoons and temperature gradients is geographically and bio-diversity wise considered one of richest area of the world.
- The productivity of Arabian Sea 1.8gramsM^2/day. This sometimes reaches 5 ec/M^2/day.
- The Indus river silt is rich in nutrients of all kinds i.e., nitrogen, potash, phosphate, calcium, magnesium, copper, zinc, manganese, iron, molybdenum, boron, sulphur, etc.
- Value of the productivity of Arabian Sea is 10 times - the value of World Oceans and 5 times that of Indian Ocean.
- The productivity of different tyrophic levels for EEZ of Pakistan with area of (270,000 km2) shows equivalent fish biomass as about 9.4 million tones.
- Arabian Sea is strongly stratified near the surface showing a gradient of 10-15°C in the upper 200 meters.
- Nutrient level in the Arabian Sea increases sharply with depth. Near the surface fertile waters are within the limits of euphatic layer i.e., 50-100 meters. The oxygen concentrations in the Arabian Sea drops sharply immediately below the euphatic zone.
- Central Arabian Sea has low productivity, with patchy production of plankton.
- Productive areas are reduced in winter.

Mixing of Red sea and Persian Gulf water with Arabian Seawater

The characteristics of Red Sea and Persian Gulf are shown in table below:

Temperature, salinity, oxygen level of Red Sea, Persian Gulf and Arabian Sea

Factor	Persian Gulf	Red sea	At entry point in Arabian sea
Temperature.	21.6C	20.5C	Red sea 18°C Persian Gulf 20.5°C
Salinity	40,000 ppm	37,500 ppm	
Temperature at surface	28.66	26.6°C	
Oxygen	2-3ml/L	2-3ml/L	

Indus estuary and sediments

The nutrient rich sediments load of Indus River had great effect on the marine life not only along the estuaries, but also along the near shore delta.
The decreased inflow of nutrient rich river water sediments as well as those dissolved in river water have affected of shore fisheries. The cause of this effect is seawater intrusion.

Eddies monsoons, south-west winds and tides

During monsoons (May to September) and strong south-west winds, large scale eddies with cold and (cyclonic) and warm water (anticyclonic) cores are developed throughout the Arabian Sea. Eddies and large amplitude waves play important role in advection of cold water from up-welled areas. Warm eddies occur in the off shore areas of Pakistan. Normal surface temperature near shore in June is 29°C. Due to tides bimonthly mixing of 20-40m deep water occurs.

Dissolved oxygen in eddy fields

Oxygen generally declines rapidly with depth, particularly north of 20°N latitude. Dissolved oxygen content also decreases at 26-27°C, signifying that oxygen demand exceeds the supply at 100m depth. Eddy fields have oxygen value of 3ml/L at 100 meters depth, showing that water trapped in the eddy field is well oxygenated and even at the thermline, where water temperatures are 26-27°C and oxygen concentration are 3.5ml/l. This means higher productivity.
The eddy field is rich in nutrients and these nutrients increase local biological productivity. In January and February circulation is anti clock wise. Any circulation helps in mixing of nutrients and absorption as well as distribution of oxygen sustainable of biological life.

Cooling of Arabian Sea

In summer, July-August Arabian Sea cools due to monsoons and is related to its intensity. Other factors for cooling are cloudiness, evaporative cooling and therefore surface heat loss, vertical mixing of deeper cool water due to high wind stirring, eddies, large amplitude waves in transporting up-welled waters etc. Large scale eddies with cold cyclonic fronts and warm cores. (Anticyclonic) are developed through out the sea. Warm eddies are found in the off shore areas of Pakistan. The eddy field of Arabian Sea also enriches upper layers of water with nutrients encouraging productivity.

Arabian Sea cooling and productivity

During peak of south west summer monsoons, cooling of Arabian Sea has been repeatedly observed. There are four major variable up-welling in the Arabian Sea namely:

- Near the Somali coast
- Near the Arabian coast.
- Near the central Pakistan coast.
- Near the southern tip of Indian western coast

The distribution of cold up-welled water in these areas is through eddy circulation making central part of Arabian Sea warm. The eddy areas have high productivity and central warm area of Arabian Sea has low productivity. It also has lower rainfall.

Oceanic Energy of Delta

- Wave energy
- Thermal energy
- Wind energy
- Tide energy in sub-equal area

If used properly they will help economy, even other wise they help in mixing of nutrients and also absorption of oxygen from atmosphere to be used by biological life in the sea.

Wave power per unit crest width at 10 m contour

Wave power as measured to 10m depth X 10^7 ergs/second in case of the Indus delta is highest in the world. This being 1000, Ganga has 850, Senegal 430, Irraaddy 250, Amazon 210, Mississippi 195, Nile 130, Hwang Ho 90, Yagtze Kiang 78 and Ord 20. This wave power has the serious disadvantage for Sindh that, while high discharge of river and its silt load kept delta advancing

into the sea at rate of 4 km. a century, with low discharge since 1960, the sea has started eroding delta. Only 2500 years ago delta was at Gujo-Pir Patho-Kadhan, it would now get eroded at a fast rate and in 500 years may hit back to Gujo. This is wave power for 10m contour, but wave power per unit crest of the Indus is slightly low and is discussed below.

Wave power per unit crest width

In terms of wave power per unit crest width of the Indus is number 4. Those being higher than it are:

Showingwave power per unit crest of various river deltas

S. No.	River Delta	Wave power
1	Magdalena.	200
2	Senegal	150
3	Sao Francisco	30
4	INDUS	16
5	Nile	11

Wave power and off shore slope

There is also another criterion in which wave power is affected by off shore slope. In this again Indus stands the fourth as shown in table below:

Showing wave power affected by offshore slope

S. No.	River Delta	Wave power
1	Magdalena.	10^9
2	Senegal.	10^9
3	Sao Francisco.	10^8
4	INDUS.	10^8

Arabian Sea Fisheries

- Catch of fish has increased seven folds but so has number of boats by twenty three times i.e., catch per boat is only one third. Even this statement is incorrect as boat size now is much bigger, with more crew. Previously, boats were on fishing trips for about 36-40 hours a week and now they spend 96 to 120 hours abroad. This makes fish catch about 5% or one twentieth of the previous.
- Per boat catch has reduced considerably to less than 1/3rd as was studied to early 1980s.
- Besides due to lack of fresh water entering the sea, over fishing has reduced the stock.
- Nutrients rich sediments to sea have also reduced.
- Fishing is concentrated in a narrow belt of marine area close to the coast and within about 60-70 km. radius of Karachi.
- EEZ extends to 200 nautical miles (230 miles or 370 kilometers) from the coast but this is not utilized by Pakistani fishermen as they do not have ships for deep sea fishing.
- Weak monsoon also appears to induce environmental changes in reduced fish stock.

- Rainfall intensity is directly related to river discharge.
- Strong off shore winds favor up-sloping of cool well oxygenated water near surface on gentle continental shelf off the Indus Deltaic region, increasing concentration of biomass near the coast and increase in demersal fish.
- Strong winds and intensive rain fall on the sea are favorable for higher fish catch.
- Failure of monsoons for 2 to 3 consecutive years reduces fish landing.

Degradation of fresh water lakes or wetlands in coastal talukas due to seawater intrusion

Coastal taluka of Thatta district are Mirpur Sakro, Ghorabari, Jati, Shah Bander and Karo Chan. Those of Badin district are Badin and Golarchi. Fresh water lakes in them were stocked with fish and they also attracted migratory birds from Siberia, Mangolia and China. Lakes have degraded due to seawater intrusion or increase in salinity due to lack of fresh water supply and even back flow of Kotri barrage surface drainage system. These degraded or threatened are; Chareno Dahee, Dhabka, Jubbo, Nurriri, Shaikh Keerio Peer, Phoosna, Khanjo, Jarei, Nira, Soomar, Sooure lake of Badin, Golarchi and Tando Bago Talukas and Haleji, Hadereo, Jafri, Mahboob Shah, Karo, Karojo, Catch and Ghunjri of Thatta distirct.

Temperatures of Arabian Seawater

Surface water temperatures vary usually between 29 to 29.5°C close to equator in the month of May and reduces in northern Arabian Sea to about 27°C in Persian Gulf countries and due to influence of evaporation and south west monsoons, temperatures as low as 22°C has been found near Equator in Arabian Sea.

There is misconception about coastal marginal area and it is not visualized that they can serve as highly economic asset. The estuarine habitat serve as spawning and rearing nursery for shrimp, lobsters and fish, which enter mangroves from the sea. Mangroves are larval nurseries for fish prawns. They also serve as wintering ground for thousands of water fowl and other species.

Chapter 5

MANGROVES AND ENVIRONMENTS

Mangrove Area

- Estimated mangroves area. 275,000 ha.
- Position of Sindh mangroves in the world was the 5th largest before 1960
- Mangroves in past four decades have deteriorated due to environmental stress in estuaries, hyper-salinity of seawater and lack of silt in water, which supplied nutrients, but now in absence of these has caused impoverishment

Mangroves and fish fauna

Mangroves eco-system also serves as feeding ground for shrimps and some fishes in earlier stages of their life cycle, subsequent to their larval development in the open sea (salinity up to 27,000 ppm).

Variation in shrimp catch

- Due to lack of nutrient silt, mangroves have deteriorated.
- Due to deterioration of mangroves, shrimp population has decreased as mangrove leaves, fruit, flowers, falling in brackish water helped to develop Artima, a food for newly hatched eggs of shrimps and also food in early stages of their life.

The figure clearly shows that:

- Before 1960, the catch was 300 tons annually

Indus delta of Pakistan, showing mangrove vegetation. Courtesy of Space and Upper Atmospheric Research Center (SPARCENT), Karachi.

per unit effort

- In 1960s after Kotri Barrage it fell to 120 ton per unit effort
- Drop continued in 1970s, 1980s and 1990s
- At present the catch is less than 20 tons per unit and continuously declining and needs to be studied further

Mangrove species, Rhizophoraceae (Rhizophora mucronata)

- The local names are Kamo, Kunro, Bhora and Timna and are ever green plant with girth of 1.5 meters. Grows with intensive thickness along tidal estuaries or salt marshes. They have prop roots or exposed supporting roots. They are wild life habitat, provide protection against wave erosion, and produce flowers, which have high nectar content for honey bees, fragrance probably to attract insects and fruit and leaves as fodder for camels and cattle
- Fruit is sweet and is eaten by people. Fruit juice can be processed in to wine. Young shoots are used as salad and cooked as vegetable
- Wood of tree is hard and durable and is used as timber for house construction or furniture, bullock yokes and plough frames. It is also good as fuel. Bark of it is a cheaper source of tannin and a powerful astringent used in pharmaceutical industry.

Local people use mangroves as fodder, fire wood and timber.

MANGROVE ECOSYSTEM OF INDUS DELTA

Common Mangrove species along the Sindh and Balochistan coast
Table below shows the common mangrove species.

Mangrove species and their habitat

1.	Avicennia marina	Sindh coast including surrounding of Karachi
2.	Sonneratia caseolaris (also Avicennia ceacea)	Mouth of Indus
3.	Aegiceras comiculatum	Mouth of Indus
4.	Ceriops tagai (Rhizophoraceae)	Sindh coast
5.	Ceriops decandra	Probably has perished and become extinct
6.	Rhizophora mucronata	Mouths of Indus

- Mangroves along Balochistan coast are limited. Aviceania marina, a tree is most common at the mouth of Dasht River Delta, Kalmatkhor, Miani Hor and Hab River Delta. It does best at salinity, of about 2.5-3%. It can survive salinity of even 8%, but gets stunted over 3%

- Mangrove area claimed to be about 263,000 hectares in 1977, had reduced to 160,000 hectares in 1990 and to 106,000 in 2003. They also have lost density and now have spare vegetation. The loss in terms of area is 60% and in terms of density another 60% at the last. Considering this, mangroves production has reduced to just 16%, due to seawater intrusion
- Responsible agencies for protecting mangroves are: Forest Department and National Mangrove Committee
- There are 8 species in the Indus delta out of 53 species in tropical forests world over
- The most dominant species in the Indus delta is Avicennia marina

The area under mangroves in the Indus delta is 249,500 hectares. Mangroves are important for the following reasons:

a) They enhance productivity of fisheries in the deltaic areas as well as adjacent coastal waters.
b) They provide spawning and nursery grounds for variety of fish and shrimps
c) They support near shore fish production along Sindh coast
d) They provide fuel, timber, honey, fruit, and fodder to local communities
e) They check soil erosion and help in land stabilization
f) Their deforestation destroys mangroves habitat, seriously reducing fisheries of shrimp and fish along the coast and also reduce Pallah (Hilsa or Ilsha) catch
g) Industry utilizes mangrove forests for manufacturing of chipboard, paper, etc. Besides Port Qasim and Pakistan Steel Mill has replaced mangroves along the Phitti, Gharo Creeks
h) Mangrove trees have ability of separating fresh water from saline water needed by its metabolism and leaves have glands which secrete salts like salt bushes. Their rate of transpiration reduces in presence of high salinity of water, but that affects their growth and trees develop stunt looks
i) Cell sap in mangroves contain 0.2 - 0.5% salt as compared to 3.6% in the surrounding seawater
j) The primary production of Indus delta g/C/m^2/year is 365-780 in the coastal areas with mangroves and only 50-200 in coastal area without mangroves i.e., around 14 to 24%. This alone is justification for preserving mangroves. The other estimate is 1500 mg/C/sq. meter/day. It is about 1-48mgC/sq.metre/day during monsoon
k) Leaves falling on the ground by their natural life limit of 1 to 4 years are consumed by variety of domesticated animals and estimated quantity is 5%, but the rest 95% leaves enter into the aquatic system of debris.
l) Protein content of green leaves is 6%. It falls to 3% at leaf fall. Debris of leaves provide nitrogen enrichment to the soils of area
m) Mangroves support invertebrate fauna, dominated, by crustaceans. Thus they are essential for larvae and juvenile of shrimps and coastal fishes
n) Large number of invertebrates such as crustaceans, gastropods, bivalves and polychaeles are permanent inhabitants of mangrove system, while shrimps and fish move in and out with tides
o) Common fauna of mangrove habitat include crabs, skippers, mullets, clapeids [sardinella, thryssa], fish, penacid shrimp and molluscs
p) Upper canopy of mangroves support a rich insect fauna together with insectivorous and fish eating birds, but they themselves become prey for large birds
q) On sea ward side and on creek bank, Gobiod fish known as mud skipper is abundant. On land ward side, crabs, gastropods and bivalve molluscs are common
r) Gastropods feed on algae growing on prop roots of mangroves.

Indus Delta area mangroves
It is the fifth largest mangrove in the world, but is dwindling.

Conservation and management of Mangrove forests

(i) Ensuring that 8.7 MAF water is allowed down stream of Kotri to protect environment
(ii) No dams may be filled and no link canals opened until this requirement is met at rate of minimum 5,000 cusecs on any day of year, which would in general be about 10 months a year and equivalent 3.0 MAF and between during July and August 6.0 MAF
(Iii) Replanting mangrove forest.

Intertidal flora
Their Primary Production is very high and about 50 times higher than that of river and sea areas and may range between 100-25g/C/sq.metre/day. They provide food for huge number of marine species of crustaceans, molluscs annelids and shrimps.

Chapter 6

MARINE FISHERIES RESOURCES

Heavy metals in the sea along the Karachi coast

Heavy metals along the Karachi coast are primarily iron, copper, zinc, manganese and they are non toxic, when in small quantities. The toxic metals are cadmium, mercury and lead. Cadmium is found to be in quantities large enough to cause concern to fish and other fauna which human being eat.

Pakistan's marine fishing resources

- Pakistan's EEZ and territorial zone measure 279,000 sq. km.
- Its high production potential is indicated by nutrients, plankton, and fish biomass
- Giant squids of more than 5 feet length have been observed near the coast
- Whales are frequent visitors to Pakistan off shore areas
- Large shoals of sardines and archives have been observed churning the turbid water off the Indus deltaic region
- Pallah fish is in high demand. It lives in nutrient rich seawater and moves into Indus water against current to spawn
- Tuna and sailfish migrate across Pakistan marine area, under influence of currents and plankton food
- Off shore deep areas (pelagic zone) has several fish species like croakers and sea becomes lantern fish etc.
- North Arabian Sea is the most productive part of Arabian Sea as described before.

Farming the sea

Though farming of sea or aqua-culture in coastal areas was started around 1400 AD in Indonesia, but progress was slow. The Government of Sindh allotted 16,000 acres of land to some 80 growers at Gharho some 50 kms south of Gharo in 1983 for prawn farming, but within four years water quality changed from maximum 27,000 to 35,000 ppm and project was abandoned. It is possible to find alternate sites for prawn farming, but no one is attempting. No attempt is being made to introduce fish culture on seawater. Milk fish is being raised in artificial ponds on seawater in Taiwan, the Philippines and Indonesia. This is a subject needing further studies.

Conservation of ocean species and their habitat

In view of fast changes along the Indus delta some ocean species are endangered to extinction and others of commercial value are being reduced due to change in habitat.

Recreational sea uses

Beaches near Karachi were used for swimming, surfing, fishing, diving, water Skiing, sailing, sports, site seeing and holidays. Due to pollution of sea near Karachi, seawater is too smelly for these sports. Indus flows in the past were large enough to remove pollutants to the sea or dilute it. New solutions have to be found.

Small pelages and demersal fish shrimp and other crustaceans
They account for 1,048,000 metric tons of which 947,000 are from Sindh and 100,000 from Balochistan waters.

Pallh (Tanualosa Ilisha) the salmon like fish of Indus Delta

- Sindh's Pallah, called Shael in India, Hilsa in Bangladesh, spends most of its life in sea, but when about two years old and mature, ascends to the Indus River to breed. It then has size of about 9 ½ inches or 24 cms. Its habitat is brackish waters of northern Arabian Sea. It moves upwards against the river current around June and when river water was available, Pallah would keep moving up to November - December. Female laid eggs in shallow river water at temperatures of 23-25°C, which were attained in October and there males fertilized them
- Eggs hatch out into finger lines and after spending 4 weeks in hatching area they enter main current on down ward journey to the sea. Since there is no fresh water down stream of Kotri in October the hatchery gets either destroyed or without productivity. Since its life is about 2 ½ to 3 years, lack of fresh water for 3 years can destroy it totally. Pallah fish catch over years is shown in table below:

Pallah fish catch in past 50 years.

Sr.No.	Year	Catch in tons
1.	Early 50s	6,500 tons.
2.	In 1980	1,859 tons.
3.	In 1985 had reduced to	928 tons
4.	In 1999 catch was	222 tons

Latest figures need to be collected, but it has already reduced to 3.3%.

- In no year since 2006 it is not more than 150 tons.

It is observed that Pallah went up to Bakhar and not beyond, but in 1831 Alexander Burnes saw it in D.G. Khan District boundaries. Pallah is brackish water fish which spends juvenile life in brackish coastal waters and moves upstream to spawn, while it also gains size. It was the single largest species of fish accounting for 70% of total catch for centuries but it could not go upstream of Sukkur barrage, which had no fish ladder. However fish ladder constructed in Kotri barrage headworks failed to work.
Pallah increases in size by 1 inch (2.54 cms) a month in the first year and growth slows down but can be about 18 inches (45 cms) at age of 3 ½ year. Its life expectancy would be around that period. Since Pallah is warm water fish as compared to temperate zone salmon, the same techniques can be applied to raise Pallah in artificial ponds.

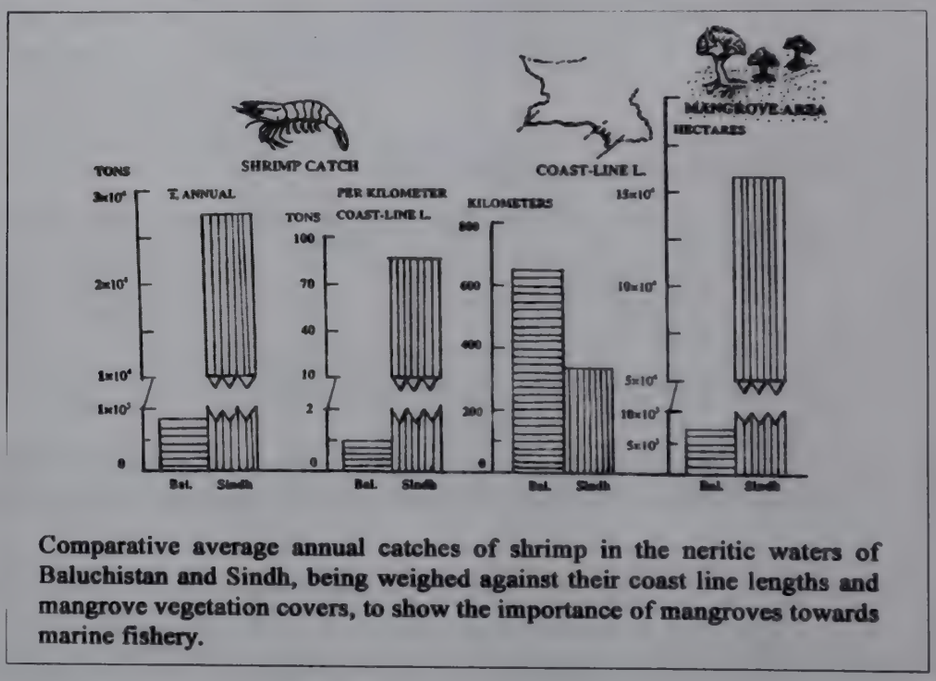
Massive algae blooms which kill fishes enmasse
The algae Prorocentrum minimum is red in colour and is known in Europe, Northern America, Japan, New Zealand, Australia, Malaysia, India, Scandinavia and England.
Red tides are not necessarily red in colour and can be colourless, but consist of micro and nannoplankton, which deprive the fishes of oxygen in water, and kill fishes, invertebrates and sea

brids. The last probably are poisoned by fungus and bacteria which multiply in their mouths and throat, where some moisture and oxygen is available for their own multiplication in warm blooded animals body.

Shrimp fishery scenario

- There are more than 7 shrimp species along Sindh coast and of them three commercially important are: Jaira, Kalri and Kiddi. Their catch in 1972 was 16,080 tons with 456 trawlers with 35.26 tons per boat and catch per unit effort was 3.56 tons. In next 20 years, the catch reduced 4.46 tons per boat as number of trawlers had increased 4 times the total catch reduced from 16,080 tons to almost half i.e., 8,107 tons and total catch per boat reduced to about $1/8^{th}$ i.e., from 35.6 tons per boat to 4.55 tons. In terms of effort i.e., total number of trawlers and total number of days at the sea, it reduced from 3.56 to 1.52 i.e., to just 42.7% upto 1995. Further data is not available.
- The delineation of unit effort of various organizations has not worked out. The formulae used for working out the total effort is Y = a + b x, where Y is total effort in days at the sea, X = number of trawlers and a and b = constant.

The formula does not take into account, size of trawlers, which has increased, the number of crew employed and area of operation.



Comparative average annual catches of shrimp in the neritic waters of Baluchistan and Sindh, being weighed against their coast line lengths and mangrove vegetation covers, to show the importance of mangroves towards marine fishery.

Depletion of shrimps along the Sindh coast

There are a number of factors causing depletion of shrimps along the Sindh coast namely:

- In 1983, Government introduced ban on shrimp fishing during their spawning season June and July, but in 1985, season ban was shifted from 20^{th} June to 20^{th} August. Due to pressure of the fishermen, the ban was lifted in 1986 and again introduced in July 1990.
- No serious efforts have been made either to execute the ban or limit number of fishing boats. In 1986/87 FAO made recommendation to avoid depletion of shrimp catch by suggesting methods and implementation practices, which have not been executed properly. These are:
  a) To stop trawler fleet expansion further than that in 1986/87.
  b) Commercial trawling in the Indus Deltaic creeks should be permanently forbidden.
  c) Closure season of one month should be introduced.
  d) Prohibiting landing of shrimp at Karachi Fish Harbour and also at Ibrahim Hydri.
  e) Processing plants should not be allowed to operate during breeding the season.

Fish landing from creeks.

- Landing from creeks in 1988 were 96,410 tons.
- In the same year catch of Barramundi a migrant fish declined from 3,000 tons to 200 tons.

- Another fish Jairo reduced from 10,000 tons in 1971 to 6,012 tons in 1993.
- The catch of Kalri shrimp also decreased by 18% from 1972 to 1999. In the same period catch of Jaira shrimp declined by 47%.
- Shel fish catch was 348,689 in 1993 and it has reduced to 64,400 tons in 2,000.

Over exploitation's of fish resources
In 1950s and 60s fishing was resorted to for about 36-48 hours a week.
Fishing is now resorted to for 24 hours of day and at least 5 days a week i.e., 120 days and fish resources have depleted.

Use of banned nets
There is Sindh Government's ban on Boolo Gujo and Katra nets. These nets are used in creeks and mangrove forests which are breeding ground for fish and shrimps. When seawater carrying large quantities of shrimp and other fish including juvenile fish enter creeks during high tide, they are trapped by these nets and killed. Fishermen take out their net after a week and dead fish pollutes seawater.

Small fishermen, fish in sea creeks, but influential people of the area, have forcibly and illegally occupied these creeks and allow some of their own people to fix Boolo Gujo nets. The influential people charge poor fisherman Rs.1, 500 per each tidal wave. There are 5,000 Boolo Gujo nets fixed from Phiti Creek to Kajar Creek. Same is case with Katra net. The problem needs enforcement of law against nets.

Over fishing in EEZ of 200 nautical miles
The EEZ extends to about 225 miles in side the sea. Licenses have been issued for deep sea fishing to long liners and big trawlers. They use long trawler nets and catch millions of tons of small unmarketable fish and dump dead fish in the sea. These in addition to pollution also spread diseases among healthy fish.

Fishing rights
The government was charging taxes according to fish catch in olden days. Some people had Sanads (Rights certificate) from the government of the day, reserving their rights to fish in a particular area free of taxes and this was also hereditary. Recently government introduced licenses and auctions under which highest bidder was granted license. This deprived genuine and hereditary fishermen of their livelihood and contractors to get more returns, over fished and over exploited the resource.

Fisheries, threat from Advanced Nations
Marine technology has progressed in the twentieth century by use of diesel engines and nuclear ship. To this may be added advancement in fishing technology namely:

- Mechanization of fisheries
- Sonar and other fish finders
- Processing and freezing of fish on the board of fishing ships,
- Sea exploration for fisheries
- Maximum sustainable yield and maximum Exploitable yield in known.

Pakistan's EEZ extends to 200 nautical miles or about 230 miles or 370 kilometers beyond the coasts and measures 110,000 square nautical miles or 148,016 square miles. This is more than 2.66 area of Sindh, but as Pakistan has not developed above mentioned technologies to exploit fisheries resources, large fishing vessels for deep sea fishing of advanced countries with large ships are exploiting and fishing the Pakistan areas illegally. Such countries are USA, France, Korea, Vietnam, Japan and many others. There are reports that some ruthless Pakistani fishermen sell their catch to those foreign vessels on high seas.

Landing of various fishes at the Karachi and Korangi fish harbours
Following types of fishes are captured from Sindh-Baluchistan coasts and the EEZ.

1. Barracuda 2. Berramundi 3. Black promfrets 4. Bombay Duck 5. Catfish 6. Cobia 7. Crabs 8. Curtiass fish 9. Cuttlefish 10. Dolphin fish 11. Eels 12. Emperors 13. Frigate Tuna 14. Groupers 15. Grunts 16. Gultar fish 17. Kawakawa 18. King Solder Breams 19. Large Croakers 20. Lizard fish 21. Lobsters 22. Longtail Tuna 23. Misc. Clupe 24. Msc. Tuna 25. Mullets 26. Queenfishes 27. Rays 28. Sallfish 29. Sardinellas 30. Sawfish 31. Scads 32. Scats 33. Sea Breams 34. Shads 35. Sharks 36. Shrimp 37. Silver Whitings 38. Skipjack tuna 39. Small Croakers 40. Snappers 41. Sole 42. Spanish Mackerels 43. Squid 44. Threadfins 45. Travelly 46. White Pomfrets 47. Wolf Herrings 48. Yellowfin Tuna

The exact catch of each of fish species is not known and needs to be studied. May be some species have become extinct in Sindh.

Fishing gears
Fishing gears used in the Sindh coast are of various types namely:
- Otter Trawler net with opening doors and is most common
- Turki is entanged gilnet used mainly to catch shrimps
- Rach is gillnet for fish
- Gujji is mall dragnet
- Jalla is cast net
- Bun is beach seine
- Kundi (Handline and long line)
- Katra is surrounding net with close table

Of these most popular are Turki followed by Trawl, Rach and Katra accounting approximately for about 35, 25, 12.5 and 10% of catch of total. Of the rest, Gujji takes large share of about 7.5%.

Number of boat operating form Karachi is largest in Sindh and Baluchistan coast accounting for almost 80%. They deplete fish sources close to the Karachi coast.

Fishmeal
Due to unscientific fishing methods, wrong type of nets, large quantity of fish is wasted and of the landings more than 20% is converted into fishmeal. The methods of producing fishmeal are not scientific and products get poor rates in local and international markets. Usual method of producing fishmeal is: **Sun drying - steaming - again sun drying - grinding - packing**. In the process large portion of protein is destroyed and ultimately only 20-25% of raw fish is converted into marketable fishmeal with about 30% price against better processed fishmeal. The situation needs a great deal of improvement.

Fish curing

Number of fish, not popular food within Pakistan are cured and exported. These include, snakes, sailfish, marlins, dolphin fish, queen fish, mackerels, trivialise, catfish etc.

The curing amounts to de-hydration with salt. The products then are exported. Since methods of curing are primitive prices fetched are very low in international markets.

Freezing

Shrimps are usually frozen for export. Shrimp export one time accounted for over 70% of total fish export. Due to seawater intrusion shrimp catch has shrunk and so the volume of export.

Lobsters and crabs

Catch of lobsters and crabs exported are very small in number - being hardly 5% that of shrimps.

Economic of Fisheries and Forest Development

Fisheries along Sindh coast

There are three major fishing seasons along Sindh coast, though they overlap each other, but are categorized according to peak production of the three groups shown in table below:

Fisheries season

S. No.	Fisheries season	Months
1.	Shrimp season	March to May
2.	Pallah season	June to September (except drought years)
3.	Trashar Gand season	October to February

The catch of all three has been progressively decreasing per unit effort, because of seawater intrusion.

Chapter 7

FAUNA AND FLORA OTHER THAN FISHES OF THE COASTAL AREA

Wild Life

There are wild animals consisting of mammals, birds, turtles. The mammals are the same as in inland forests and fields of Sindh. They are more or less resident of mangroves and nearby villages and fields. Of them the following are more common.

* Asiatic jackal (Canis aureus) * Balochistan Gerbil (Gerbillus nanus) * Indian Gerbil (Tatera indica) * Finback common or common rorqual (Balaenoptera physalus) * Gazella or Indian gazella common (Gazella gazella) * Indian broad beaked dolphin or electra dolphin (Syn: Peoponocephala electra (Lagenorbynchus electra) * Indian crested porcupine (Hystiz indica) * Indian desert gebrill (Mericones Lurianae) of following sub groups: * Bush rat (Gollunda ollioti) * House mouse (Mus musculus) * House rat (Rattus rattus) * Metad (Rattus mettada) * Sand coloured rat (Rettus gleadowi) * Indian hare (Lepus nigricollis) * Indian hedgehog or pale hedgehog - Lasbela Coast (Paraechnus micropus) * Indian pangolin or scaly anteater (Manis crassicandata) * Indian wolf (Canis Iupus) rare * King fox (Vulpes cana) * Little Indian porpoise or black finless porpoise (Neomeris phocaenoides). It has been seen in late September up to April all along the Makran Coast * Plumbeous dolphin (Sousa plumbea). This is the most numerous dolphins at Sonmiani 31 stranded dolphins were counted during the 3 months peirod February-April 1985 * Pygmy sperm whale (Kogia breviceps). It has occasionally been observed in the Bay of Oman - southeast of Gwadar * Sand fox or Rupeeli's fox (Vulpes rupell) - rare.

Reptiles

There is complete absence of large reptiles namely; Marsh Crocodile (Crocodylus Palustris) and Gharial (Gavialis Gangeticus), both of which is fresh water animals in Sindh and has become extinct below Kotri barrage, but some lizards and terestrial snakes are common in some creeks and dry areas or swamps of mangroves. Pleagic Sea snake is also present in Deltaic creeks, but is not too common. All this loss of fauna is attributable to sea water intrusion.

The change of Delta from river dominated to wave dominated is going to erode the coast. The wave energy along the delta is very strong and may push coastal area by 10 kms or more per century, unless large quantity of water is allowed to flow down stream to Kotri year around.

Turtles

Two types of Turtles green turtle (Helonia Nidas) and Olive Ridley (Lepidochelys Olivacea) are found along Karachi, Hawksbay and Paradise Point. They are endangered species and efforts being made to protect them by Sindh Wild Life Management Board and the World Wild Life Fund (WWF) are the most prominent in this regard.

Ocean Birds

Of the 8,600 bird species of the World 300 are truly marine. Of the latter, there are 3 categories divided according to habitat. First category is that which feed near the coastline and forage in land (pelicans cormorants, skimmers, most gulls and coastal terns) Second category is that which live on fish in off shore waters (penguins, petrels, gannets, boobies and frigate bird). The Third category is which frequent open sea and spends most of their lives on wings (batrosses, shear water and petrels).

Then there are sea birds which nest on land they include clif ledges or niches tropic birds, cormorants, gulls and auks; greasy slopes (skuas, garnnets, albatrosses and phalaropes), burrows (shear waters, most petrels and some penguins) bushes and trees (cormorants, frigate-birds and noddies), coastal mangroves (pelicans), shandy shores sand dunes (some terns). Now with lower productivity due to water quality change from 27,000-36,500 ppm, reduction of nutrients of river water, drying up of some wet lands others turning very saline in past 25 years, the bird habitat has changed sufficiently and bird population has been affected but a deep probe is yet to be done.

Birds of Indus delta

In addition to migratory water fowl and sea birds, mangroves provide food and shelter to a number of endemic species of birds. Some of them are also migratory. These are:

- Oyster catcher
- Lessor love sand plover
- Greater sand plover
- Grey plover
- Golden plover
- Little ringed plover
- Rentish plover
- Sanderling
- Dunlin
- Curlew
- Whimbrel
- Marsh sand-piper
- Sand piper

Breeding activities of a number of endemic birds have been reported in the coastal wetlands of delta particularly of the following:

- Little Tern
- Common Tern
- Gullbilled Tern
- Yellow legged herring
- Lesser black backed gull

Food for some of migratory and endemic species namely; Brahmany kite, white tailed sea eagle, ring tailed fishing eagle, pavid kite and osprey is, mud skipper fish and grepsid crabs. With dwindling mangrove and reduction of food, the population of above birds is going to decrease. In order to conserve these beautiful birds, their habitat i.e., wetland, swamps and mangrove forests have to be conserved.

Endangered species of coastal Sindh.
This will include study of:

- Turtles (3 species discussed above)
- Marine Mammals (dolphins and other fishes)
- Sea birds (discussed above)

Mangrove fauna and flora.
Mangroves support the following:

- More than 207 species of fish
- 56 species of birds
- 500 species of macro invertebrate

Chapter 8

EARTHQUAKES, TORNADOES AND STORMS WATER

Earthquakes along the Indus Delta and Baluchistan Coast

Coastal area of Sindh is in active seismic zone. There is geological fault from Ahmedabad and Bhuj and Ormara along Makran coast and another geological fault from Ormara to Gulistan about 80 kms west of Quetta to Jalalabad and then turning eastwards under Himalayan foot hills through Kohistan towards Haryana in India and beyond. It is called Karakoram fault. Another one is located Abbottabad, Mansehra, Kohistan and Swat district. The 2005 earthquake was more intensive than 1974 earthquake, which had created havoc in Pattan, Duba, Palas and other villages. The first causes earthquakes along the northern Gujarat, Kutch, Rann of Kutch and affects Sindh coast and Karachi. In 1945 earthquake with epicentre in Makran between Pasni and Gawadar, Karachi also got shocks and some islands along Baluchistan coast disappeared and new one emerged. The 2001 earthquake destroyed many houses in Ahmedabad, destroyed almost the whole town of Bhuj and affected coastal area of Sindh including damage to some buildings in Nagar Parker, Islamkot, Mithi, Diplo and Badin and bridges on roads south of Badin, though figures of such damage have not been published.

The 1819 earthquake is well recorded and survey of Sindh Coast by Carless in 1817 and again in 1837 showed lot of changes in the various branches of the Indus. Beside these Sindhri a coastal town on the eastern branch of the Indus called Puran leading to Lakhpat on Koree Creek, submerged about 6 meters below the water in the Rann of Kutch and Rann of Kutch got disconnected with sea due to rise of its western edge close to and turned into inland lake. During this earthquake a mound 16 kms wide 80 kms long and 6 meters high, rose across the Puran blocking water supply to Lakhpat for some nine years, when the bund due to water pressure breached again in 1828 AD and channel leading to Basta and Lakhat and Koree creek was restored. This bund was locally called Allah bund (God's embankment).

Mud geysers were recorded at south of Jati in 19th century, showing volcanic activity down below. The Sindh and Baluchistan coasts therefore are to be watched against seismic activity. The zone of active seismic zone is shown in the above mentioned maps.

Earthquake related hazards

Seiche

Another phenomen is Seiche (sash) which occurs in enclosed body of water like lake or partially closed bay like estuaries or creeks of Sindh coast. In these waters earth quakes cause pendulum like oscillation of water. Such oscillations can cause knocking down of trees, eroding ground to nearly level of bed rock. These must have occurred along Sindh coast, and done lot of damage, but are not properly recorded as the area is backward.

Ground displacement by earthquakes

Ground displacement and fissure is also connected with severe earthquakes, but usually it is largely surface layer of unconsolidated materials which get displaced and not the deep rocks.

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Land slides caused by earthquakes

Land slides due to earthquakes are also common in mountainous regions, but uncommon in the plains where land uplift or Sinking down occurs and such cases are considered to be responsible for dunes of Thar Parker and Umer Kot districts. These dunes run in south-east-south direction parallel to each other.

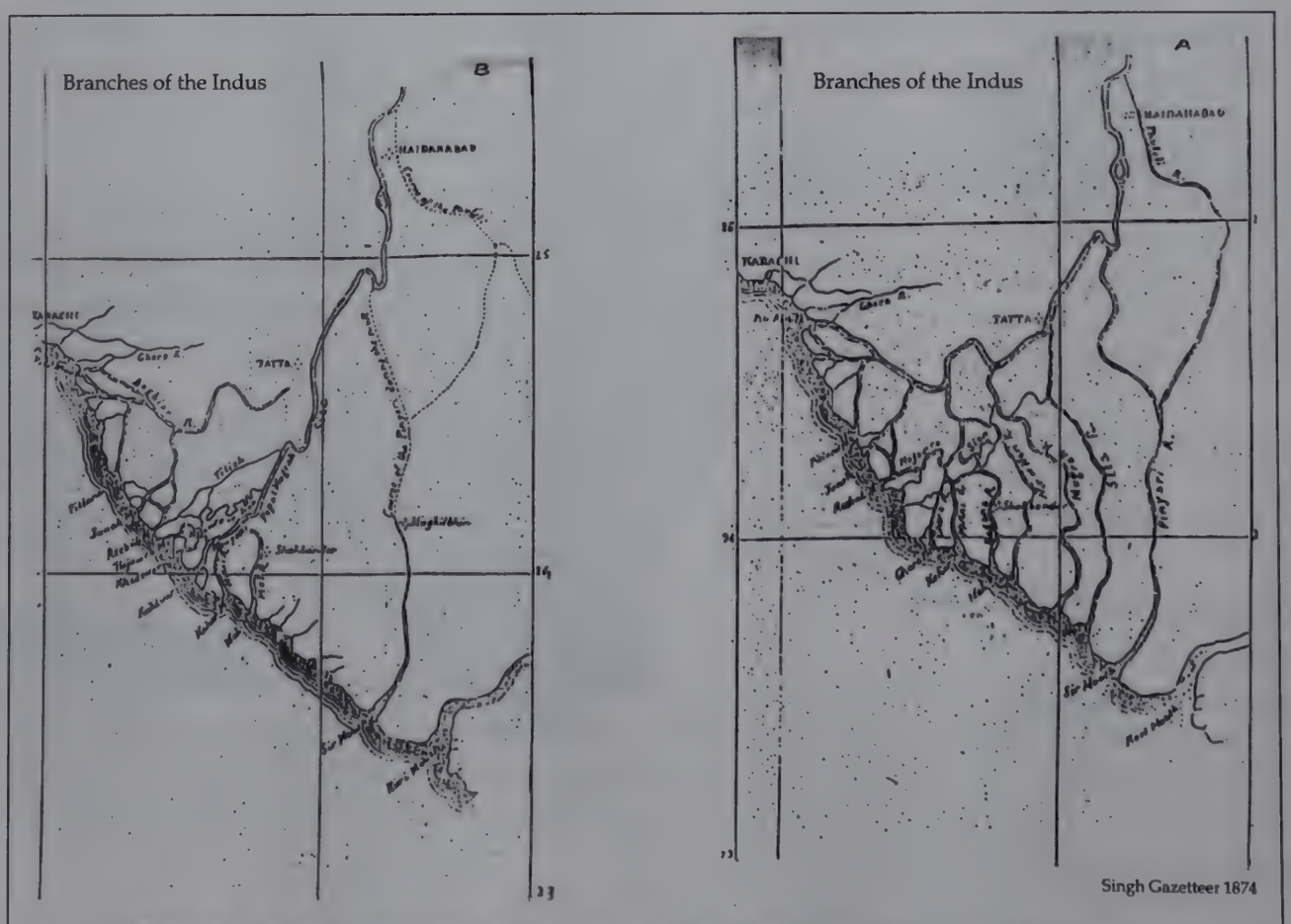
Mud volcanoes caused by earthquakes

Mud volcanoes occur, where there is fine grained soil material saturated with water. It turns into thick mobile like matter. The process is called liquefaction. It rises through fishers and erupts as mud volcanoes. The liquefied sediment can flow out from beneath tall buildings, which then tilt slowly many single storey houses were collapsed, but exact damage along coastal areas is not known. The clay that erupts is already heated by warm volcanic action and turns light. It has a number of applications in construction and industry, but use of this material has not been made by construction industry in Pakistan, though it is available along Makran coast and possibly near Jati, where mud volcanoes occurred.

Historical earthquakes in coastal area of Sindh

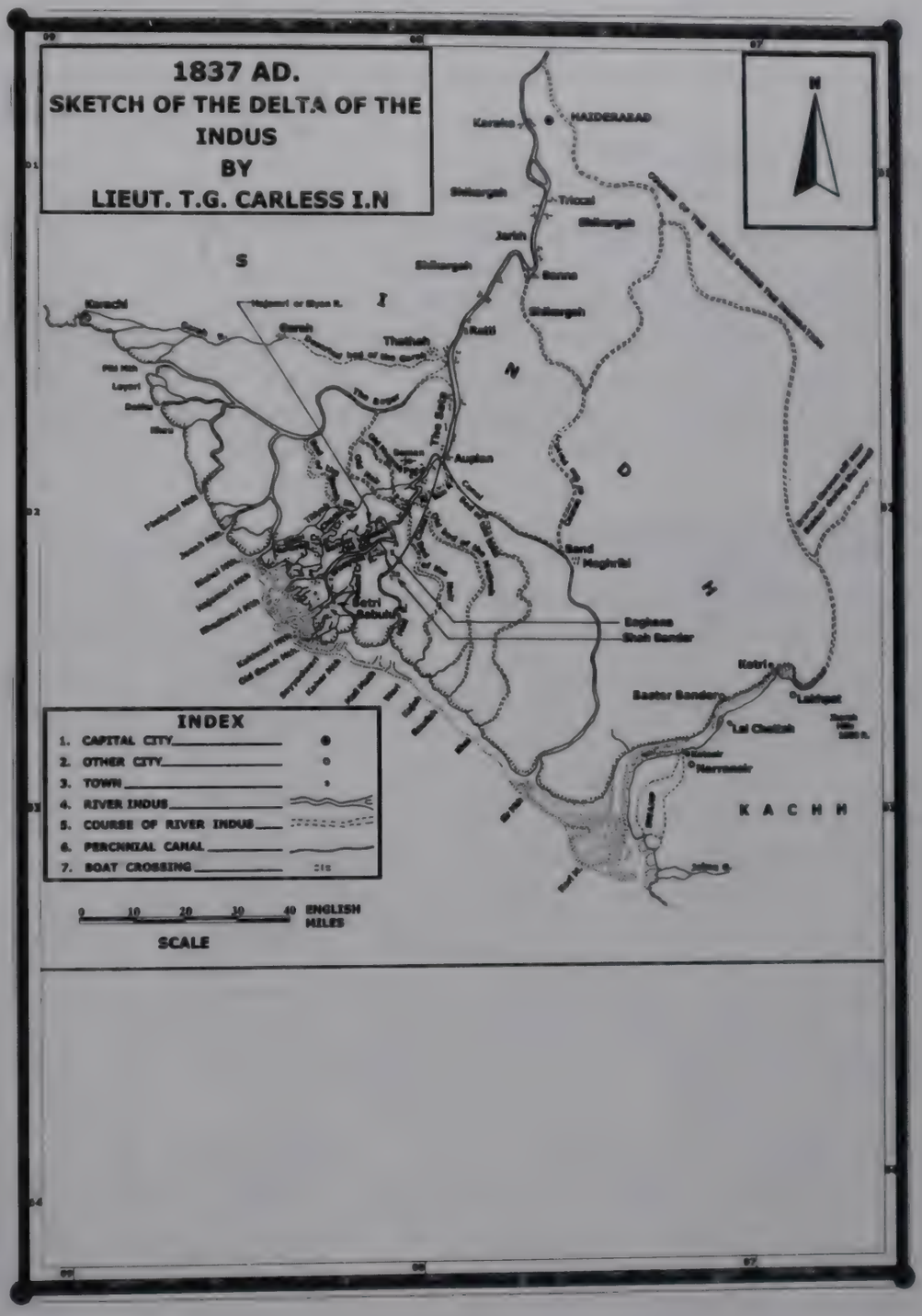
1819 AD, Earthquake in Rann of Kutch bordering Sindh

It occurred on June 16, 1819, an eye witness account by the British officers, informing that 7,000 buildings were demolished, 1,150 person were buried alive in the ruins. A shallow stream about



Changes in the Course of the River Indus From Position in 1817 (A) to Position in 1837 (B) Due to the Earthquake 1819

7,000 feet (2133 metres) wide was formed and Rann which was previously disconnected with sea was filled with seawater spreading to large area. Sindri fort 15 feet high above water level, and a Talpur border check-post (now in India), was submerged nearly totally and custom officers on the fort wall were rescued by a British ship. Total displacement of Allah Bund was 30 feet uplift and 10 feet depression due to vertical slipping at the fault plains. The earthquake is reported to have disbursed normal drainage pattern of Rann of Kutch and river Indus and the Indus River branches to the sea changed their course as can be seen from coastal maps of 1817 and 1830 AD.



Due to 1819 earthquake Shah Bunder port was abandoned and two new creeks namely Kukaiwari and Kadewari came in to existence between 1819 and 1837.

1901 AD Earthquake

The 1901 earthquake caused fissure in alluvium in Badin and Jati Talukas. Warm water and mud gyser erupted for about 12 hours. The gyser holes were 15-20 feet wide and 8-10 feet deep. Records about damage done to houses, roads etc., are not present in Sindh Government records now. Search for them can give useful information for future.

1956 AD Earthquake

Another earthquake in Rann of Kutch took place on July 21, 1956 at a place called Anjar 80 miles south east of Allah Band and caused great damage to life and property.

Earlier Earthquake of 1668 AD

In 1668, a severe earthquake caused major topographical changes in the Rann of Kutch and loss of life and property and possibly some damage in coastal Sindh.

Indus lineament and effect of earthquakes

Snelgrove thinks that Indus lineament is responsible for change in the original course of the Indus 1758 AD. This earthquake is thought to have caused shift in the course of river to the one that it follows today but these hydrological changes were already taking place since 1755 AD and Kalhoras changed their capitals a number of times during a few years.

Hurricanes or Tornadoes

Coastal area is within hurricane zone, which strikes Sindh coast, Kutch, Kathiawar and some parts of Gujarat periodically. There is lack of record of such hurricanes in the past, but May 1999 AD hurricane struck not only coastal areas of Thatta district, but sufficiently inside. The waves were considered much more than 18 feet high and submerging all areas upto 18 feet contours but suddenly with little notice and warning was issued and there was loss of human lives and domesticated animals. The land once submerged into seawater, needed fresh water for washing salts out and vast area of Kotri barrage containing sea salts which in time have been converted in to sodium bicarbonates and carbonates, needs costly reclamation. It is still awaiting reclamation.

History has recorded such a hurricane in days of Shah Jehan when vast areas of present Thatta and Badin districts were submerged and Emperor had to send special funds for help of people.

Many such cases are reported periodically in the past 23 years, when warnings have been issued, but luckily the hurricane got diverted towards Rann of Kutch or Kathiawar, the hilly shores of which reduced impact and

Map showing location of the Indus Plains, the delta and the distribution of annual rainfall

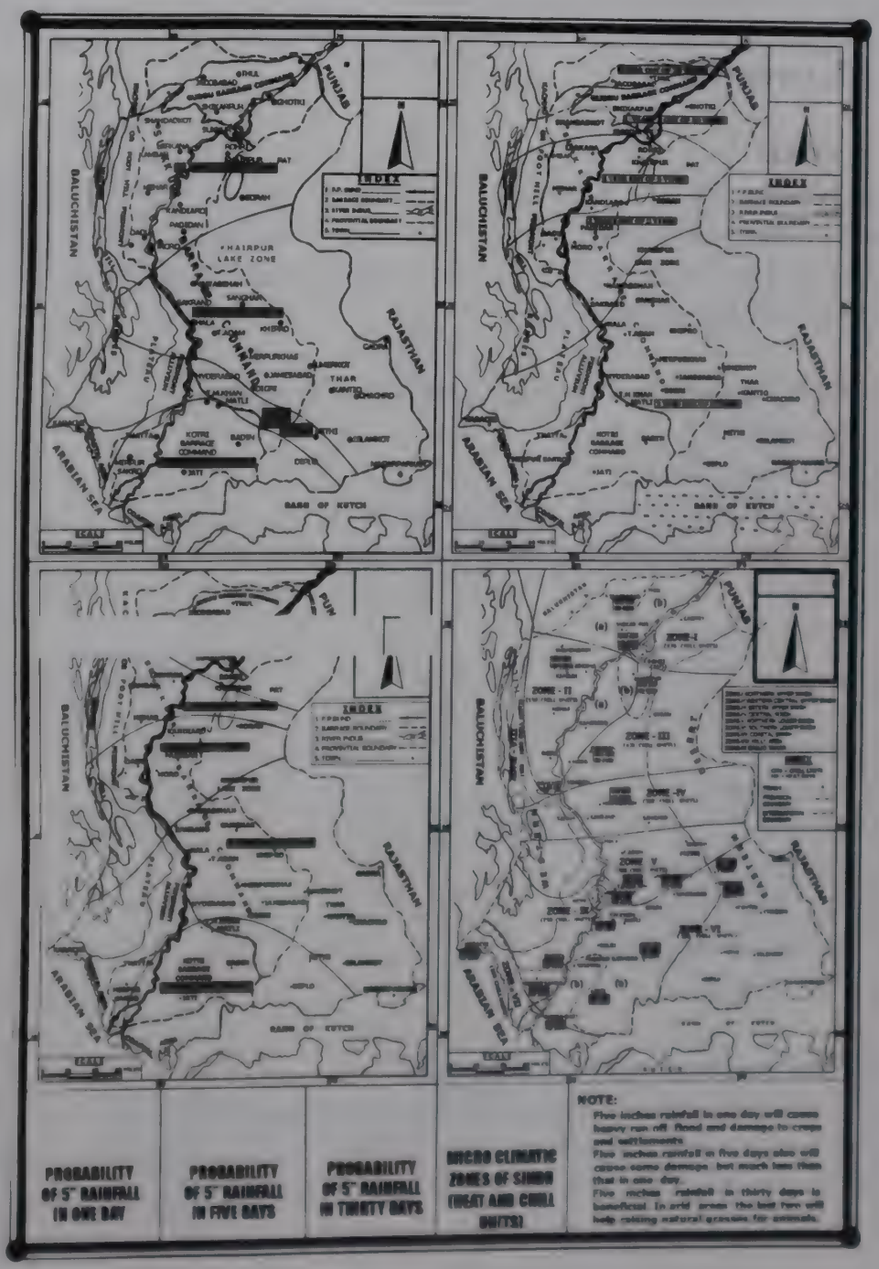
damage in those areas. It is proposed to study exact area which was submerged in 1999 and work suggests:

- Land reclamation procedures.
- Future warning and evacuation system.

Storm water

climate of Sindh show the coastal and near coastal areas and they show that there can be a rainfall of five inches within 24 hours once in five years, which will certainly cause floods. The coastal housings of wooden branch-lets as walls and thatched roofs can not stand any rains more than 1 cm a day and inspite of common use of plastics as a layer above the roof, the houses leak, every thing inside the house including clothing becomes wet, cooking can not be practised easily, as wood too becomes wet. One effect of rains is spread of diseases like malaria, cholera, dysentery, diarrhoea throat and lung infections etc.

Annual average rainfall is 7-8 inches on the coast near Karachi, 8-9" in Ghorabari and 9-10" in Shah Bander and Karo Chann, all of it falling in about 7 days of July and August. Thus it is annual occurrence of misery to the people of area. Should houses be designed and built, to face the periodic and regular storm water problem, there could be considerable reduction in human misery.



Heavy floods due to heavy rains in the catchment of Indus and its tributaries have occurred in 1821, 1828, 1841, 1858, 1874, 1890, 1892, 1895, 1913, 1916, 1921, 1926, 1929, 1942, 1948, 1955, 1957, 1959, 1973, 1975, 1976, 1977, 1995, 2003 and 2006, almost 21 times in 182 years, i.e., once in every 15 years. There is occurrence of five inches rainfall in one day once in 5 years in Thatta and Badin districts including their coastal areas as aforesaid. This caused severe floods, loss of at least some domesticated animals, housings and field crops. Proper drainage can take care of it.

Chapter 9

ECONOMIC RESOURCES, MINERALS

Economic benefits of seawards delta

a) Brackish coastal water benefits in terms of good growth of crustacean i.e., shrimps, crabs, lobsters, giant prawns and oysters
b) Brackish water fishes, the Pallah-Salmon of tropics thrives in them
c) Seawater fisheries
d) Oyster beds
e) Pearls
f) Invertebrates other than insects
g) Miobenthos a relatively new study of coastal zone
h) Sea weeds

Sea weeds

Sea weeds are an extremely diverse group of organisms and their lipid composition and metabolisms are varied. There are a number of sea weeds present along Sindh coast. These weeds besides fatty acids have all kinds of nutrients including micro-nutrients. Sea weeds presence of varies with salinity of water.

Economic benefits of land wards delta (Botanical)

a) Mangroves
b) Sea weeds (Kelp)
c) Sea plants on which sea fauna survive
d) Mangrove Habitat-as food web relationship
e) Algae
f) Minerals

Economic chemicals of Deltaic Sea

a) Nitrates
b) Phosphate
c) Silicon
d) Hydrogen sulphide
e) Sulphur dioxide
f) Phosphorite sources
g) Oil and gas

Mineral resources of Makran coast

Makran coast extends from a little west of mouth of Dasht river (25°-11'N, 61°-40'E) near the Iran-Pakistan border to Hab river on the Sindh border. The mineral deposits of the coast are black sand containing ores like, Zircon, Limenite, Rutile, Monazite, Garnet, Chromite etc. These sands have 2 to 40% minerals ores adjacent to mouths of the rivers Dasht, Shadi Kaurs, Hingol and Phor and

shoals near Pasni and Soanmiani. There also are sea shell deposits, which have use in pharmaceutical industries and for high potency calcium tablets and syrups.

Another good item is non swelling clays in coastal zone of Baluchistan, between Ormana and Pasni and Pasni and Nai. There also are lightweight clays which bloat at 1000-1300°C and then have weight of ½ that of clay itself. It can be used in construction. These types of clay are available in the coastal Zone of Baluchistan and originated from mud volcanoes, which were naturally heated and are classified as lightweight aggregates having weight almost half of than commonly available else where and are lighter than water and so float on it.

Chapter 10

OCEANOGRAPHIC ARCHAEOLOGY

Seawater intrusion and archaeological sites

Archaeological sites exist along sea coast. Earliest site as recorded in books is probably Alexander's Heaven, founded in 325/24 BC, which survived well above 1500 years and was burnt by invader Jallaluddin Khawarism Shah in 1222/23 AD to loot and collect wealth to re-invade the country he had lost to Chinges Khan.

Its founding is 325 BC, was period of drought and sea level was low and when excavated by Director of Archaeology in 1957/58, foundation were submerged four feet below the lowest level he was able to dig and according to him excavated level went back to about 100 BC. Climate had improved in Sindh from 400-700 AD, but cold prevailed from 700-900 AD and again another cold period began form 1350-1850 AD. New ports were established on the Indus branches during this period, but they were not submerged by sea, as high quantity of water flowing from the Indus had produced its own counter effect. Since past 30 years the coastal sites are being destroyed by seawater intrusion and high wave action. The names of various coastal sites as known from various sources are:

1) Jangi Sar
2) Keti Bunder sites
3) Faki Bunder Juno Shah Bander
4) Rato Kote
5) Mulakikot
6) Darya Pir
7) Dunheen Waro
8) Banbhore
9) Morgha
10) Thambhan Wari, Masjid
11) Shodi Shah
12) Pir Khamba
13) Muhammad Shiraz Mag
14) Dhuhari Pir Rukan Mag
15) Khulyal Masjid
16) Shaikh Nariya Mag
17) Milko
18) Mannipir
19) Ratokot

This is a rich archaeological sites treasure. Many of these towns had survived more than 1000 years and others are about are 500 years old. Banbhore (Alexander Heaven) is 2040 years old and was continuously occupied and had survived at least for 1550 years.

Satelite picture showing land accretion and erosion zones along the coast of Sindh.

Oceanographic Archaeology

Oceanographic archaeology can be divided into two groups, geological history of the Indus, and archaeological sites in the deltaic area during historical or proto-historical period. The delta head started near or above Brahmanabad or Patala 2500 years ago and any site below it become archaeological and coastal but here only those sites close to coast and within coastal area are to be considered, as they were on the coast in the past 1000 to 1200 years, but were encroached upon by sea, either due to rise of sea level or erosion or political causes. The latter is not so important, as those eroded or submerged in the sea due to rise of sea level after end of the Little Ice Age (1300-1850) and warm period from 1850-2006. To these includes Keti Bander, Shah Bander, and Larhi (Lahri) Bander, each of which has more than one site and existed during past three hundred years. Next to the earlier sites are Jangirsar Jak or Juna Shah Bunder, Rato Kot, Mulaki Kot, Bambhore, Darya Pir, Thamban Wari Masjid etc. Although all of them have decayed either due to encroachment of the sea or abandoning of site by the river Indus.

The reason for their submergence is that 650-900 was a cool period and so was 1300-1850 AD. The latter was so cold that it is called Little Ice Age. During the same period temperatures were low, glaciers had advanced land wards, rainfall was less, river flows were low and sea level had fallen. On rise of temperatures these settlements got either submerged in the sea or were destroyed by wave and tide action. Since 1850 AD it is estimated that sea level rises by 1.1 millimeter a year and this could be rise of sea level by about 165 millimeter or about 6 ½ inches.

The purpose of investigation is just to locate the sites rather than explore or excavate them, but they all show seawater intrusion after river abandoned them. These would be reported to Department of Culture Government of Sindh as well as Archaeology Department Government of Pakistan and Shah Abdul Latif University Khairpur, Karachi University, both of which teach archaeology, Sindh University, Peshawar University and other Government functionaries including Coastal Development Authority and Irrigation Departments.

Chapter 11

POSSIBILITIES OF DEVELOPMENT AND GAPS IN INFORMATION

Possibilities of development after collecting data or information

- Sea weeds or Kelp can be used as animal feed, micro-nutrients for agriculture, disease control in humans etc., and processing of it, will be an important source of income and additional natural resource.

- Aquatic weeds could also be used as fish and animal feed, fibre, energy, making mats, curtains and also their use in waste water treatment and human food.

- Use of Organic wastes of fish, forest and agriculture available locally can be processed as food, fuel, feed, fertiliser and for soil enrichment.
- In addition the following fisheries technologies could be developed to help local population:
  - □ Boat design, construction, and propulsion.
  - □ Fishing methods and gear.
  - □ Fish processing.
  - □ Artificial reefs and fish aggregating devices.
  - □ Algae, harvesting.
  - □ Sea farming.
  - □ Sowing mangrove from air in areas of deforestation and as per experience gained from Australia.
  - □ Control over predators.
  - □ Post-harvest food losses, their assessment, and control. in case of:
    - _ Fisheries.
    - _ Timber and fruit from mangroves.
    - _ Providing education and training.

Rural infrastructure development of the Coastal Area in Thatta and Badin Districts

Thatta and Badin are very backward districts of Sindh. Water logging, salinity, lack of perennial water in most of the area and also shortage of water in the perennial areas have kept the districts backward. The area is also prone to heavy rainfalls some times. There can be more than five inches rainfall in one day in one out of five years. The rainfall causes flood, sweeping away animals, washing away housings in the towns and villages and some time area remains submerged under water even for two months after the rains. The storm water usually chokes up drainage system, bridges, canals, cuts off roads and paralyses the life. Ruination of economy is usually complete after every such rainfall. Situation in areas near the coast is worst in such rains than in the inland.

It is proposed to provide infrastructures to help people in over-coming all such problems. Provision of infrastructures like a roads, electricity, post and telegraph office is responsibility of the government. In similar way provision of schools is a responsibility of education department and electricity of WAPDA. The infrastructure proposed therefore would make provision of centers where the people meet discuss the problems. The centers could be provided in selected areas and would be meeting places between people and various departments. This will also lead to creating awareness among people and also will be a vehicle for education and training.

Coastal road from Karachi to Badin

There are 17 creeks in coastal area of which 14 are in Thatta and Badin districts. Of these nine are 20-30 kilometers, four 14-19 kilometers and one is 90 kilometer long. Their width varies between 250-2500 meters, but they usually are more than 700 meters wide. One creek is 5000 meter wide at the coast and 2000 meters wide inland-ward. Their depth varies between 5-30 meters. It is not practical to have road crossing the creeks by bridges, but a road can run along the coast out side tidal zone and link roads can be built in peninsulas in between the creeks. This is type of road network is used in USA along the Gulf of Mexico. There will be many economic, social and political advantages of such a roads. This road has to cross the river Indus and possibility of combining it with a weir across the river to stop tide water intrusion in side the river has to be investigated. Such a road will definitely open-up the area to the urban people interested in investment, but can also bring opportunities for the rural people for employment and for rural people to migrate or trade with urban areas. The following are the possibilities of the development after this road is commissioned:

a) Development of fisheries in the creeks as well as continental shelf including deep sea fisheries by Pakistanis.
b) Development of animal husbandry.
c) Development of mangroves.
d) Development of oil and gas in the continental shelf as well as inland wards.
e) Development of wind and tidal power as Sindh coast has greatest potential of tidal power development in the World.
f) Development of minerals at the sea bottom.
g) Development of fresh water giant prawns in fresh water ponds.
h) Development of shrimp culture along the creek.
i) Development of seawater fisheries.
j) Development of fresh water fisheries.
k) Development of villages and towns along the coast.
l) Protection of wild life.
m) Development of archaeological sites.
n) Protection of environments.
o) Development of tourism, recreation and holiday spots.
p) Development of agriculture and value added crops in the coastal areas.

With these advantages, which can lead to development of the area within shortest possible time this could be a major project for coastal area.

Suitability of coastal area for horticulture development

We have studied that the climate of coastal zone area around Keti Bundar, Ghorabari and Shah Bundar has semi-tropical climate being more than 1°C cooler than Karachi Airport and Thatta in

summer and warmer in winter. The maximum temperatures in summer do not go beyond 38°C and minimum temperatures do not fall below 13°C. In such climate we can grow tropical fruits, nuts, industrial crops, vegetables and even algae crops, which do not grow in the sub-tropical climate of Sindh. Such climate does not exist elsewhere in Pakistan.

An advantage of climate can be taken to grow value added crops, after carrying out the detailed studies of their climatic requirements as well as yield, marketing and economy. Experiments elsewhere in Sindh have shown that, though rest of Sindh is not suitable for cashew nut, avocado, macadamia nut, etc., this area happens to be highly suitable. In addition many other economic fruit and other crops can be grown in the coastal areas.

Collection of general data to fill gaps information for planning

Protection of coastal resources could be achieved by collecting information, understanding problems, studying other factors, monitoring all impediments, consenting, enacting and enforcing laws, introducing new methods and technologies and training for example:

i) Collecting information on breeding of fish and shell fish.
ii) Carrying out scientific studies on feed, feeding and growth of fish and shrimps.
iii) Collecting information on productivity potential.
iv) Understanding impact of reduced input of fresh water and sediments from the Indus and methods of conservation, to off set these adverse effects.
V) Renewing interest on shrimp and other fish farming studies Impact of proposed jetties, agro based industries and power plants based on; wind, solar, wave and tide water.
vi) Studying sea level rise along the Pakistan coast, tidal variations, loss of land in past 50 years.
vii) Monitoring pollution of coastal waters.
viii) Conservation of endangered species.
ix) Managing mangroves and coastal forests.
x) Implementation of Government Acts, and Laws with regards to ban on fishing during some periods of year, connected with breeding.
xi) Checking and stopping over fishing of shrimps.
xii) Stopping gill-net fishing.
xiii) Reducing fishing pressure on small pelagic fishes such as Indian oil sardines and anchovies which form 60% marine catch through indiscriminate fishing, waste through poor handling and use as fish meal.
xiv) Introduction of better fishing techniques for harvesting of non conventional fisheries such as squids, cuttle to ease pressure on demersal fishes.
xv) Collection of statistics by improved methods and field surveys.
xvi) Study deep sea fishing methods and training.
xvii) Assessment of stock of demersal fishes.
xviii) Assessment of stocks of commercial species of Molluscs for exploitation.
xix) Assessment of catch per unit effort for commercial fishing operations in the coastal waters.
xx) Assessment of available fish stocks in EEZ (Exclusive Economic Zone) of Pakistan and coastal water.
xxi) Studying records of occurrence of rare, frequent or abundant fish varieties.
xxii) Finding out seasonal and temporal distribution fauna and flora.
xxiii) To study life cycle of common marine species with commercial, local or export potential and also recreational interests.

Xxiv) Breeding patterns and feeding habits of common species.

xxv) Study of ecological conditions along various sections of coast and adjacent oceanic areas.

xxvi) Comparative studies on distribution of fauna and flora in polluted and non polluted environments.

xxvii) To suggest solution to reduced discharges of the Indus water have definitely lead to pollutants from Karachi and badly affected environments and marine life, which other wise would have been diluted by river waters and damage could have been negligible or much less.

xxviii) Collecting baseline data from marine and coastal areas.

xxix) Suggest conservation strategies and environmental protection safe guards.

xxx) Survey of living resources for identification priorities for major issues of conservation.

xxxi) Control over exploitation of resources as well as of original settlers of area.

xxxii) Suggest fisheries regulations and effective implementation.

xxxiii) Measures to protect endangered marine and coastal flora and fauna.

Xxxiv) To suggest plan to improve mangrove forests.

xxxv) To create awareness among all stakeholders, the government organizations, political organization local settlers, marketers, exporters, packers etc.

xxxvi) Last but the foremost is study of Environment and its Impact.

Possibilities of Development

The development possibilities are directly related to government policies, investment of private sector and protecting rights of stakeholders, enactment and enforcement of existing laws and agreements and introduction of new laws. These will apply to existing and future needs and will be revised from time to time, but never without consultation of original settlers, who are sons (daughters) of soil, have lived there for innumerable generations and are now being forced out and migrate due to decline and destruction of environments and are no longer able to make minimum sustainable living. The action needed will be:

i) Implementation of fisheries laws.

ii) Free access to local people to coastal areas and resources by promulgating suitable laws.

iii) Facilities for waste management, especially of the urban waste entering the sea at various points and also of dumping dead fish in the sea, including use of illegal nets etc.

iv) Proper management of LBOD and RBOD Out Falls in the sea and management of estuaries in which they fall.

v) Assured release of 8.7 MAF of water to the sea annually as per recommendation of Arbitrators in November 2005. The arbitration is biding on all provinces of Pakistan and Federal government.

vi) Any dam on any river of Indus should be built only after meeting the water requirement of lower riparian i.e., Sindh and Balochistan, which represent coastal areas too and flow of minimum 8.7 MAF with flow no less than 5,000 cusecs on any day of the year.

vii) Mangroves to be replanted with suitable varieties.

viii) Provision of clean water to all villages of coastal area atleast at one point.

ix) Campaign to reduce effects of fertilizers and pesticides, flowing into LBOD and RBOD and entering estuaries.

x) Alleviation of depletion of fisheries by various methods.

xi) Control of pollution of cities and settlements along all Pakistan Rivers, which flow into the river Indus and cause health and environment problems.

xii) Strict control on types of nets, which are harmful and illegal.

Xiii) Creating awareness among deltaic people of their rights, problems and solution.

Chapter 12

SOCIO-ECONOMICS

Establishment of data bank of social, environmental and development indicators for the Coastal Area districts of Sindh, Thatta and Badin

There is lack of data about socio-economic, environment and development indicators of the coastal areas of Sindh. The area is inaccessible due to submergence under tidal influence of daily, monthly and during monsoon winds and also changing of topography from time to time. The Agriculture Census data since past 40 years are based on sample surveys of various Talukas and they do not apply to the coastal area, because of non-uniformity with non-coastal areas of Talukas. The census data are equally distorted as the people of coastal area go out the sea or to irrigated area for work and most of coastal settlement are not easily accessible, except by complicated routes from creeks to estuaries and walking through high dry lands. The unreliability of the data is so much, that no two authorities have so far given same data for area under mangroves fish, shrimp and Pallah catch. The studies have therefore to be done into socio-economic, socio-environments, natural resources, all kind of economic resources like land and water, division of labour, infrastructures and educational institutes if any, women as head of family, to build data bank for future occupations, labour wages, grazing animals, handicrafts etc.

Socio-economics

Lack of basic facilities in rural area settlements like; water supply, sanitation, drainage, communications and health etc., all due to:

- Salt water intrusion in the delta.
- Low literacy rate.
- Feudal and tribal system.
- Low income group population and poverty.
- Local resources not under control of local population.

Suicide cases

Poverty, helplessness, exploitation and no way to get out of these problems has lead to many suicide cases in young, both males and females. Some thing like 100 cases of suicide a year from coastal area is indication of extent of seawater intrusion and violation of human rights.

Diseases

Due to polluted or brackish drinking water stomach diseases, dysentery, indigestion Diarrhea, typhoid, intestinal Helminthes, anemia and renal diseases are very common. Other diseases are malaria, acute respiratory track infections, pelvic inflammation hepatitis A and B, measles, mumps, acute flaccid paralysis, neonatal titanus, urinary tract infections, skin diseases like scabies, allergic eczema, anemia, malnutrition, cydes, sub-mucosal fibrosis, oral cancer, and anxiety neurosis. Dog and snake bites are also common.

Biodiversity losses to coastal Taluka

Water shortage and sea intrusion has caused loss to following species in coastal talukas of districts Badin and Thatta some more, other less as given in table below.

Sr. No.	Class of biodiversity group	Details of groups
1.	Agriculture	Motya, Ganja Kharai, Kangni, Namnyoon, Sugdasi (high quality rice), Ather, Nar Bajra, Jawar, Makai, Mung, Masoor, Katri, Manh, Urd, Chaunra, Kara Mung, Aran Wari, Carrot, Lahori Gajar, Gawar, Janbho, Sarah Achhi, Tooryon, Hern, Trachha, Tirkan, Kanderi, Niswa, Jaan, Cheno, Manjhell, Hurbo.
2.	Herbs and shrubs and grasses	Daneenh, Dangni, Dabhar, Bart, Mandbano, Makhni, Mundheri, Mundhero, Mot, Moth, Mangryl, Gangni, Pawari, Span, Deer, Sorathi, top, bakeeh, Lepar, Bukan, Bhegro, Dhamoori, Lichan, Kalooro, Danbh, Bhechiti, Ubat Kandri, Tikundri, Kitabibi, Mahmeezo, Lunb, Uth Lari, Gadlai, Khariai, Kharaho, Chabro, Lueen, Gur-ryal, Weh, Dhod Phal, Cheno Doleh, Golaro, Sanu, Puchar Gah, Kirangh, Kanheen, Sir, Kango Dhunar, Kootak, Bhatal Rafki, Bhatal Singh wari, Mor Bhatal, Khap, Oyn, Khunbh, Jogira, Wan Werhi, Be Pari, Tooh, Jhang Meha, Chibhur, Pipoon, Phonphari, Loonak, Kur Peroon, Raban Pan, Jhang Khathoori, Saatoni, Mithal Koni, Karal Khoni, Pabun, Loolar, Run Jee Bajree, Kal, Moth etc.
3.	Trees	Kirir, Knah, Kandero, Gedoori, Dhalyar, Asri Lau, Jar Kheri, Jasadoi, Gidamiri, Burir, etc.
4.	Birds	Hanj Mero, Hanj Neergi, Dhaunri Meri, Dhaunri Ganeri, Cheeklo Mero, Khobai Cheeklo, Geno Malanng, Chotooro, Khagh, Kainro, Gor, Doheero, Pen, Saris, Koonj, Hokaaro, Tindri, Aree, Kungh etc.
5.	Reptiles and insects	Cobra, Gado, Lundo Mero, Lundi Khapur, [snakes]. Damar, Karo Wichhhon, Jau, Jhari Tindri, Garhi Golari, Jau, Kengho, Kari Tidi, Achhi Tidi, Denbhoo Karo Nor etc.
6.	Mammals	Jhang Bilo, Pasalo Bilo, Thar Jaho, Goh, fox, pig, Sando, wolf, Charakh, rabbit, Sirh, black mouse, Kuo Meto, dear, gazelle etc.

Chapter 13

RECOGNITION AND MANAGEMENT PROBLEMS OF AREA

Recognition of problem for development of fisheries and livestock
General Description

The Sindh coastal zone includes in-shore as well as off-shore land and sea areas, measuring many thousand square kilometers and which directly and indirectly provides livelihood to many millions of people all over the country, besides contributing substantially to national economy. The area had long mangrove forest stretching along the sea coast and embankments of creeks and which was the 5th largest in the world. It has started deteriorating in the past 30 years due to dilute or brackish seawaters turning saline. The process had started 40 years back, but worsened after 1975. It has not been studied as an integrated whole unit.

The wet coastal land is unique that it is penetrated by some 16 major tidal creeks, some of which are about 30-40 kilometers long and none less than half of this length. Their width varies between 250 to 2600 meters and depth 5 to 10 meters. The creeks also have their estuaries which inter-connect almost all of them, covering the area in small but unstable and always changing islands. Under high tide conditions, with exception of high spot settlements, the whole coastal area becomes sheet of water with small isles scattered all over. It is wetland by definition and in reality.

The major occupation of people is fisheries, followed by animal husbandry. Wood collections from mangroves also form an importance source of income to the local population. The gradual mechanization of fishing industry starting since 1950s, has now turned into large fleets, owned, manned and operated by urban capital, management and labor, affecting coastal settlers adversely, and even with this equipment their catch per unit effort has reduced to less than one third and income in spite of long working hours, has reduced to below poverty line. The poor are exploited by boat owners and middle men (who advance money for operations) and lastly by market agents. Even these three categories in turn are exploited by very rich, who advance loans and due to political influence, easily get loans from banks for the purpose.

Problems involved in fisheries development

A large number of creeks which actually are old beds of the river Indus at the delta are an untapped economic resource. They support vast number of fish fauna, but these also are not properly exploited in absence of:

- No control on exploitation of fishermen by contractors, boat owners and wholesale marketers.
- Lack of organization among the local settlers and farmers.
- Lack of points where fish could be collected for onwards shipment to Karachi and other markets.
- Lack of fish harbors or fishing jetties in the area.
- Lack of cold storage to hold fish until it is shipped to the markets in Karachi and abroad.

- Lack of cold storage transport.
- Lack of grading and processing facilities at above places, to reduce wastage and process waste material for other uses.
- Lack of government organizations and fisheries extension services to help the local population involved in fishing and fishing trade. The same service can help in other sectors like mangrove forestry, livestock and rural uplift.
- Lack of incentives, availability of suitable fishing gear and boats to help in fish catch.
- Lack of modern facilities for pond culture to convert creek and estuaries into artificial ponds for fish farming or creating artificial ponds out side the estuaries.
- Lack of nurseries for fresh, brackish and seawater fishes and other fauna.
- Lack of suitable means of communications, i.e., roads and telephonic communications for helping the people and lack of infrastructures for handling fish in the creeks.
- Where natural lakes exist and are fed by water from sea or drains, there is lack of artificial feed for fish to enhance production. The natural lakes depending only on natural feed produce only 5-10% of what could be done with artificial feed.
- Lack of control over, excessive harvest of fish, shrimps, and lobster and other crustaceans, oysters, mussels, mantis and crabs and maintenance of fish catch quality.
- Pollution of some creeks and lack of controls to reverse the process.

Need for fishery jetties at some of the creeks near the coast

It is well known that the water in the 5 out of 17 creeks of Sindh coast is totally polluted, but that of balance 12 creeks are less polluted. The waters of Liari, Korangi, Charo-Phiti, and Chan Wado are more polluted and Khuddi is partially polluted. Water of rest of rest 12 creeks yields substantial quantity of fish, but it takes long times for the trawlers and fishing boats to carry them to Karachi. One of the defects of these boats is that to be economical, they have to get certain volume of catch, before returning to the harbor. A few boats carry ice to preserve the fish, but neither the quantity of ice or its temperature is low enough to keep the catch fresh. Solution to the problem is to have alternative fisheries jetties on various creeks, but start could be made with one creek on right and one on left bank of the river Indus. From these jetties fish could be hauled to Hyderabad within two hours. The jetties could provide ice as well as cold storage facilities and refrigerated transport to Karachi and Hyderabad, for onward shipment to up-country. The main purpose of the proposal is to provide fish, free from polluted waters in the neighborhood of Karachi, to the people of Karachi in shortest possible time and in most hygienic condition. In addition to provide assistance to poor local settlers, who in the grip of urban capital have been ruined.

Agriculture in the Coastal Zone

Coastal area near Ghorabari and Keti Bundar has unique climate where minimum January temperature are much above freezing and maximum summer temperatures are below 38°C as compared to 45°C at Hyderabad and 49°C at Jacobabad. Many fruit crops can grow in Ghorabari and Shah Buunder, which can not grow any where in Sindh, provided the land is well drained, water table is at eight feet depth and fresh water is available. The crops which could flourish in such an area and locality are:

- Avocado.
- Cashew nut.
- Macadamia nut.
- Pineapple.

- Coconut.
- Palm oil.

The last crop can grow in adverse conditions between Sakhro, Shujawal, Jati, and Ghorabari but will not produce economic crops. A number of other fruits, vegetable and field crops can grow in the same area and they need trials. The task involved will be the following:

- Preparing plans for improving existing agriculture.
- Introducing value added crops in the semi-tropical areas of coastal zone.
- Introduction of halophyte and sea-weeds to improve economy.

Salicornia

It is a oil plant growing purely on seawater and has been grown successfully in India, Kuwait, Saudi Arabia, Mexico and some Latin American countries. It was tried on Sindh coast and total failure occurred, as instead of 100% seawater low salinity water was used. Project failed in a way that it grew, flowered, but did not from seed.

Why coastal area is important?

- Under the present water crises of controversy over Kalabagh and other dams and water allowance below Kotri and Arbitrators Recommendation of allowing 8.7 MAF of water with minimum of 5000 cusecs, i.e., about 2.0 to 2.4 million acres feet during October to April (both inclusive), coastal area will become more important than then in the past 40 years.
- Exclusive Economic Zone extents to 200 nautical miles towards the sea. The present fishing equipment used in Pakistan is not for deep sea fishing.

Management of coastal area

The non point pollutants of coastal waters are:

- Pesticides used in agriculture.
- Grazing of animals in the mangroves and on coastal mangroves and other grasses.
- Irrigation and drainage.
- Timber harvesting.
- Construction.
- Roads.

Management measures to protect against pollutants

- Pre-harvesting planning.
- Stream side management of fisheries, forest and agriculture crops.
- Site preparation and forest reconstruction.
- Fire management.
- Re-vegetation management of disturbed areas.
- Aqua-culture pesticides management.
- Wetland forest management.

Management measure for urban areas

- Storm water drainage management.
- Impact of urbanization.
- Erosion and sediment control.
- Construction site management and disposal of materials used in roads, highways, bridges and housing.

Management for Marine improvement, tourism and recreation facilities

- Toxicity in water column.
- Increased pollution levels in aquatic organisms.
- Increased pollution levels of patho grasses indicators.
- Disruption of sediment habitat.
- Water quality assessment measures.
- Shoreline stabilization measures.
- Storm water management measures.
- Sewage management measures.
- Solid waste management measures.
- Fish waste management measures.
- Liquid materials disposal management.
- POL control management measures.
- Boat cleaning management measures.
- Public education management measures.
- Boat operation management measures.

Management measures for hydromodification and shoreline erosion.

- Canalization and channel modification measures.
- Channel erosion and sediment coastal management measures for chemical and pollution control.
- Management measures for surface water quality control.
- Stream bank and shore line erosion management control.

Management measure for riparian areas and vegetated treatment system

- Management measure for wet lands.
- Management measures for riparian areas.
- Management measures for vegetated treatment system.

Monitoring and tracking techniques to accompany management measures

- Monitoring objectives.
- Monitoring approaches.
- Sampling techniques.
- Data collection by sampling and testing procedures.
- Data analysis.

Chapter 14

PLAN FOR DEVELOPMENT, COMMUNICATIONS, WATER SUPPLY AND RESTORATION OF MANGROVES

Aims and Objectives

- To prepare Master Plan for development of Coastal zone.
- To establish an appropriate and replaceable planning and management framework of coastal resources with the involvement of coastal communities to ensure equitable and sustainable development.
- To redefine broad objectives for under taking integrated coastal zone management among major stakeholder.

Suggested future plans

It is proposed to have future plan covering the following:

(i) **Wetlands.**
Conservation and sustainable development of wetlands and exploitation of wetland resources such as flood control conserving non-polluted water for communities depending upon the wetlands, maintenance of coastal wetlands to keep the shoreline intact and prevent sea intrusion, protect inland settlements against tidal wash and storms sustained development of inland and marine fisheries for maximum exploitation of resource and to cater for communities livings within the biosphere in particular and raising the productivity of the coastal area in general.

(ii) **Mangrove improvement.**
Reforestation of coastal mangroves, riverine forests and irrigated plantations of Thatta and Badin districts lying between inter-tidal zone and extending as far as left bank of river Indus.

(iii) **Agriculture and livestock.**
Improvement in agriculture and livestock sectors for increased productivity.

(iv) **Drainage.**
Improved and reinforced surface drainage in coastal areas through network of tile drains, lined watercourses, construction of small dams in irrigated areas bordering coastal belt to reduce seepage and water logging so as to keep the coastal zone biologically dynamic and productive.

(v) **Infrastructure.**
Development of infrastructure in coastal areas such as roads, power and potable water through desalination plants for drinking and industrial requirements.

(vi) **Man power development.**
Strengthening of institutional and professional capacity building of existing organisation.

(vii) **Demarcation of coastal zone.**
Demarcation and survey of coastal areas using satellite imaginary.

(viii) **Investigating power resources.**
Development of renewable energy resources such as wind generators, solar energy panels, harnessing ocean tide currents, land and offshore drilling to tap fossil fuels and exploring mineral deposits such as phosphate and etc.

(ix) **Preventing coastal and sea pollution.**
Prevention and abatement of coastal and marine pollution through environmental monitoring, solid waste water treatment, solid waste management and etc.

(x) **Socio-economic uplift.**
Socio-economic development through education, health masses awareness and etc.

(xi) **Preserving cultural heritage.**
Preservation, of cultural heritage and development of coastal tourism.

(xii) **Legislation.**
Review and update legislation for integrated coastal zone management.

- Use Developed countries experience as model for (i) to (xii) above.
- Cropping pattern to be changed.
- Study of all old studies.
- Treatment of 750 cusecs of industrial waste.
- UNDP coastal zone.
- Unemployment and poverty alleviation in rural area.

Studies

- Variation in the Indus river discharge and hazards.
- Environmental and harvesting stress on fish stock in Pakistan.
- Productivity of Arabian Sea.
- Arabian Sea cooling and productivity.
- Arabian Sea and its relationship with south west monsoons and productivity.
- Oil slick damage to Sindh.
- Sediment discharge from the Indus River to Ocean, past, present and future.
- Coastal Impacts of climate change.
- Impacts of climatic change on seawater intrusion, including sea level rise.
- Sea level rise and Sindh's concern.
- Indus delta eco-region invertebrates (crustacean, crabs, lobsters, prawns and oysters).

Information on coastai area to be collected for study of socio-economic

- Formation of coast.
- Advancement of coast.
- Recent retraction or erosion of coast.
- Coastal area. Taluka wise\population.
- Languages.
- Castes and tribes.
- Climate.
- Rainfall and agriculture or pasture.
- Animal grazing and breeding.
- Insects, snakes, amphibians, fauna and flora.
- Sand dunes.
- Ground water, wells and ponds.
- Irrigated Agriculture.
- Salt mines.
- Festivals and Melas.
- Local literature written on oral.
- Artists and entertainers.
- Sports.
- Wild games.
- Schools (male and female), students.
- Primary and secondary school and students.
- Religious schools.
- Education in English language.
- Technical training and Audio-visual schools.
- Local handicrafts, including knitting embroidery.
- Post and telegraph officers.
- Police stations, check posts.
- Rangers, navy etc., affecting people.
- Veterinary hospitals.
- Health facilities for people.
- Large and small permanent villages
- Religious institutes.
- Local politics.
- Trade, Trade articles, traders and customers.
- Pirs and Murids.
- Food and clothes.
- Ceremonies from birth to death.
- Locals in government and private jobs.
- Migration due to seawater intrusion.
- Beggars, jugglers, eunuchs.
- Workers in various local trades like carpenters, blacksmiths, barbers, washerman, potters, Syeds, Pirs, gold and silver smiths, masons, boat repairers.

Chapter 15

Environmental Parameters of Water of Soil

Introduction

Clean water is essential for human survival as well as for aquatic life. It is used for irrigation, with lesser amounts for municipal, industrial, and recreational purposes: only 6% of water is used for domestic consumption. An estimated 75% of the population of developing nations lack adequate sanitary facilities, and wastes are commonly dumped into the nearest body of flowing water. Pathogens such as bacteria, viruses and parasites formulate these wastes as world's most dangerous environmental pollutants: water-borne diseases are estimated to cause about 25,000 deaths daily. Water quality data are, thus, essential for the implementation of responsible water quality regulations, characterizing and remediation of contaminations, and for the protection of the health of humans and aquatic organisms.

Indus Institute for Research & Education (IIRE), is working on water related issues and consequences of sea intrusion and water quality, in the coastal areas of Sindh. In this connection surveys were conducted in Kharo Chan and Keti Bandar region of Thatta and Badin and Golarchi taluka Badin district in order to assess the water quality. Mr. Shafique Ahmed, Geochemist and Researcher, was assigned to analyze the physical and environmental parameters of water and soil to assess the water quality in the region. Samples from both districts were collected, pH and environmental temperature was also recorded.

The sample size, collection, preservations and analysis were conducted according to the standard methods of water quality testing. The sources of water samples were hand pumps, reservoirs, rivers, canals and lakes. The water samples were analyzed for physical, contamination and heavy metals in water. The physical analysis of water covered color, electrical conductivity, pH, temperature, TDS and Salinity. The following heavy metals were studied in the water collected from Thatta district only. Cadmium, Lead, Copper, and Nickel. In general the physical quality of the surface and groundwater was not found good except in few cases where the hand pumps were installed at the banks of the watercourses but heavy metals were found beyond the WHO water standards. The soil samples were collected from Badin district were at the depth of 18 inches in tow zones 9 inch each (9 inch from the top layer and then 9 inches after first), thus 23 sample from top layer and 23 from bottom to top, the samples were collected in plastic bags for the lab analysis. The geographical location was also recorded with GPS. The heavy metals were analyzed at Centralized Resource Laboratory, Department of Physics, University of Peshawar and conductivity, TDS, and salinity were analyzed at Geochemistry lab, National Center of Excellence in Geology University of Peshawar.

Geomorphology of the Indus Deltaic region

The entire Indus sediment cascade has its origin and evolution tied intimately to the Himalayas. The general geographic relationships between mountain uplift to erosion and Sedimentation have

long been of great interest to geographers and geologists because of the new ideas about causes and effects of uplift and erosion in the Himalayas to understand the topographic evolution as well. Thus the role of erosional processes in the Himalayas is not only vital to an understanding of its geomorphic history but also to understand some fundamental processes of the tectonic evolution of the mountain chain. Indus delta formed in the result of sediment trapping of river Indus in to Arabian Sea since million of years. The geological history of river Indus is associated with the rapid tectonic uplift in the region that has led to the formation of Himalayan Mountains. The Arabian Sea was formed during the late cretaceous as the Indus tectonic plate separated from Madagascar and moved northwards. The river Indus has large geographical phenomenon. The effects of its sediments and water discharge can be seen obviously in the coastal zone of the ocean as well as in the deltaic region in terms of water flow, sediment deposition and biological activity. The fan and the Arabian Basin of which it forms the seabed are surrounded by the shallower seabed topography of the Owen fracture zone and the Murray Ridge on the west and north, the chagos laccadive Ridge in the east and Carlsberg Ridge in the south. The lower deltaic plain (Indus delta) stretches inland from the coastline to the furthest point to which, Seawater is driven by the very high tides during the southwest monsoon winds in summer. This area, which is regularly covered by seawater during high tide period, consists of tidal creeks with raised edges that are covered with small mangrove trees growing on sandy-silty sediment.

Hydrology

The Indus Delta consists of seventeen major and minor creeks and extensive mudflats that are under stress due to lack of a coordinated management plan and consequently harsh natural environment. Extensive use of fresh water for irrigation in recent years has caused a decline in the Indus River discharge. Construction of barrages, dams, and link canals has reduced the freshwater flow downstream from 180 billion m3/year to less than 43 billion m3/year (IIRE 2006)

Historically River Indus used to flow at its own causing flooding of vast Indus plain extending as far as up to Thar Desert in east. Realizing devastation and damage caused by floods, protective embankments were constructed on both sides of river during British regime, during 1900 to 1910 to regulate the flow of river. River Indus bear the worlds biggest and most intricate irrigation system comprising of three huge dams, fourteen barrages, eight major inter-river link canals, and dozens of weirs and siphons, about 57,120 kms of canals to irrigate about 41 million acres (16.5 million hectares) of land from northern most parts of the country to the deltaic regions of Sindh.

Before the advent of British rule, irrigation in the region was through inundation canals. Diversion work started around the middle of 19th century, the Upper Bari Doab Canal on the Ravi being the first in 1859 followed by Sirhind Canals, the Lower Chenab Canal and the Lower Jhelum Canal during 1885-1901, Paharpur Canal and the Upper Swat Canal were opened in 1908 and 1914 respectively. The Triple Canal Project commissioning the Upper Jhelum, the Upper Chenab and the Lower Bari Doab Canals were commissioned in 1915 and marked the completion of the first phase of work on major tributaries. The second phase marked the taming of Indus itself with the completion of the gigantic Sukkur Barrage in 1932 and the Sutlej Valley Project (11 canals and four headworks) the same year. Haveli Canal Project (Trimmu Headwork's) on the Chenab was completed in 1939 and the Kalabagh Barrage in 1947. After the independence three more barrages were built on the Indus - Kotri in 1955. Taunsa in 1958 and Guddu in 1962. Of the three reservoirs, Mangla Dam on the Jhelum was the first to come in 1967 with the cost of Rs. 5 billion and storage

capacity of 6.8 MAF. Chashma followed this on the Indus in 1967 with the cost of Rs. 4 billion, storage of 1.8 MAF. Finally came the Turbela, also on Indus, in 1974 cost Rs 25 billion and a live storage of 11.9 MAF. With the implementation of the Indus Water Treaty (1960) Pakistan was left with three rivers viz, the Indus. the Jhelum and the Chenab. All rivers rise in spring and early summer with snowmelt and monsoon rainfall and have a combined peak discharge in July or August. The Indus, which is primarily supplied by glaciers, is subject to least seasonal variation through its maximum flow in more than 50 times its minimum (Ministry of Environment 2006). The River discharge to the delta has decreased drastically over the last 10 decades.

The influence of the Indus river system on the marine fisheries of the Sindh coast is substantial as this river has historically transported enormous quantities of water, nutrients and sediments on to the continental shelf. With the establishment of barrages and dams across the Indus, the annual river flow into the ocean has been radically reduced, mangrove forests are rapidly disappearing and the potential negative effects on many species of marine fish and shrimp that rely on the delta

Satellite image of Indus Delta, June 7, 2006
Showing the mouth of Indus river and various creaks are also visible

for part of their life cycle are large. The diversion of Indus waters for irrigation uses has radically altered the Indus delta area over the past decade and average salinities have increased sharply in the tidal creeks (Asian Development Bank).

Sindh has 215 km long coast, Delta covering Almost 85 percent of the total coastal belt of Sindh, one of the largest deltas of the world. The rest of the coastline (15%) in the northwest constitutes the western coast of Karachi. The Sindh coastal belt has a population of about 8.5 million. This

area harbours more than 60% of the industries of the country. A number of industrial complexes, trade centres, two seaports, coastal agriculture, and country's main fishing centres with two fishing harbours are located in the coastal belt of Sindh.

Sources of water pollution in Indus Delta

There are many types of pollutants in the Indus Delta but the main categories of the pollutants reaching to the coastal areas of Sindh, major sources of pollution affecting Indus Delta are as under:

1. Sewage and municipal wastes
2. Industrial wastes
3. Agriculture wastes (Fertilizers, pesticides insecticides, etc.)

Sewage and municipal wastes

The main pollutants in the sewage and liquid wastes from municipal and domestic sources are high BOD organic compounds, suspended solids, detergents, phenolic compounds, pathogenic bacteria sulphur compounds, etc. The total amount of wastewaters generated by the municipal and Industrial sources from Karachi city is estimated to be 292 MGD. About 111 MGD is generated by the Industries in the area. Assuming 55-50 percent losses about 158 MGD reaches the coastal waters. About 42 MGD enters into the coastal waters through Gizri / Korangi creek via Malir River, and about 116 MGD enters into the coastal area through Karachi Harbour via Lyari River. Despite having sewerage system the sewage in Karachi is not adequately treated. There are two sewage treatment plants in the city each having a capacity of 20 MGD. Moreover, both the treatment plants cannot treat more than 40 MGD or about 15-20 percent of the amount of raw sewage, the rest of the 80-85 percent of the sewage received at these plants are discharged untreated into the adjacent Lyari River and Malir river respectively which ultimately reaches to the coastal waters. Beside some liquid wastes generated in the coastal areas other than Karachi through domestic usage are estimated to be about less than 3 MGD and about 5 MGD from Industrial sources in the coastal towns of Sindh except Karachi are therefore discharged untreated to the adjacent canals/creeks.

Industrial Wastes

More than 6000 units, about 60% of the country's industries are located along the coastal belt of Karachi and Indus delta. Most of these industries are located in the four industrial complexes. The Sindh Industrial Trading Estate (SITE) is the largest complex, located in the north and northeastern part of city. In the southern part of the city three major industrial complexes i.e. Korangi Industrial Area (KIA), Lapdhi Industrial Trading Estate (LITE), and Pakistan Steel Mills complex are situated along Gharo and Korangi creek. In addition, there are a number of major coastal Industries such as four power plants of Karachi Electric Supply Company (KESC) and Karachi Shipyard and Engineering Works (KSEW), Sindh Alkalies, two Oil refineries, Pakistan steel mills and two major sea-ports (Karachi Harbour and Port Qasim) and Karachi Nuclear Power Plant (KANUPP) which discharge their waste water effluent directly to the adjacent body of coastal waters. With the exception of only a few industrial units almost all of the industries are discharging their effluents untreated into the sewers or directly into Lyari River, Malir River and adjacent creeks. It is estimated that about 158 MGD of effluents are discharged into the coastal waters of Karachi from the industrial and municipal sources. The total waste water effluents

from KIA, LITE and adjacent areas have been estimated to be about 42 MGD. Out of which about 22 MGD are contributed by the industrial effluents. The liquid wastes entering the Indus Delta from Industrial and Municipal sources from the coastal areas of Sindh excluding Karachi is estimated to be less than 8 MGD. There are variety of pollutants occurring in the industrial wastes, the pollutants of more concern are heavy metals (Cr, Pb. Hg, Cu, Zn, As) and their compounds, Polychlorinated biphenyles (PCBs), Plasticisers, Phenolic compounds, lubricating oils, chlorine, and various organic and inorganic toxic compounds. A large sugar mill recently established has started production. This is generating a large quantity of high BOD organic wastes that are being discharged untreated into the adjacent Ambroh creek, Deh Ghorabari Distt Thatta of the Indus Delta. This area has been considered as apart of potential shrimp farming area, some shrimp. Farms established nearby are collecting water from Ambroh creek and its tributaries required for growing shrimps. The effluents from such industries are an area of considerable shrimp culture potential is likely to affect the growth and production in the shrimp farming in this area.

Agriculture wastes

The Indus River System is being used as a dumping place for most of the urban, and agriculture wastes from the cities and sites located near the Indus River and its tributaries. Most of the organic wastes are degraded within the Indus River. However, the slow degrading organic wastes and some of the inorganic wastes find their way to the Indus Delta through the Indus River discharge. The most important pollutants from this source appear to be the residues of fertilizers, pesticides, and insecticides. The varieties of fertilizers, pesticides, insecticides, etc., being used in Pakistan. It is evident that almost all types of fertilizers and pesticide insecticides are being used into the agriculture areas of Sindh and Punjab. It is estimated that about 0.5% of the pesticides used per year (e.g. 12,756 tons) are washed away and reach to the delta through the Indus River, agriculture water seepage, and runoff during floods. The amount of fertilizers used in Punjab province is 1,234,500 tons/year and about 6,000 tons of pesticides and insecticides per year are also being used in the agriculture sector in the province of Punjab. This source is estimated to contribute about 0.5% of the total amounts of fertilizers used each year (e.g. 6,172 tons) and 0.05 % of the pesticides (e.g. 43 tons), which reach the Indus Delta each year. The total annual input of the agriculture wastes reaching the Indus Delta are about 18,928 tons of fertilizers, and about 125 tons of pesticides and insecticides, and considerable quantities of other compounds from this source. Open drains for to dispose of the agriculture and storm run off, also disposes the effluent at the delta (see Table-1 Discharged of Kotri Surface Drains).

Designed Discharged of Kotri Surface Drains

Name of the Drain	Designed Discharge (in cusecs)
1. Khui Gharo Outfall Drain	950
2. Jam Sakro Outfall Drain	686
3 Ghorobari Outfall Drain	940
4. Ochito Outfall Drain	1,300
5. Nagan Dhoro Outfall Drain	282
6. Jati Outfall Drain	1,232
7. Karo Ghungro Outfall Drain	1,232
8. Fuleli Guni Outfall Drain	1,594

Source: WAPDA-LBOD

DISTRICT BADIN GENERAL GEOGRAPHY

The district derives its name *from* its headquarters town Badin, It is located between 240 13' and 250 12' north latitudes and 680 21' and 69" 20' east longitudes, It is bounded on the north by Hyderabad district, on the cast by Mirpurkhas and Thaparkar districts, on the south by Rann of Kutch which *forms* international boundary with India, and on the west by Hyderabad and Thatta districts. The total area of the district is 6726 square kilometers.

The district is a part of Lower Indus plain formed by the alluvial deposits of the Indus River. Being a vast alluvial plain, its land is very uniform in character and is not diversified by hills or rivers. The southern part of the district is close to the delta of the river Indus and the land surface is. Therefore, relatively low as compared to the northern half. The general elevation of the district is about 50 meters above sea level. Clay and sand arc principal ingredients of the soil and one of the two factors by which the composition of the various soil is differentiated is the extent to which the clay or the sand predominates. The other criteria of the character of a soil are the presence or absence of natural salts. These occur in every taluka but are formed in greater quantities in the south of the district. Matli is generally on a higher level than the adjoining taluka of Tando Muhammad Khan (Hyderabad district) and Tando Bago of this district and unlike them presents an uneven surface, long rolling indulation of not great height or depth succeeding each other through a large area from east to west Tando Bago is a vast alluvial plain. It is generally low lying and well watered. The whole taluka is swampy deltaic land impregnated with natural salts. There is no river or stream in the district.

Climate

The climate of the district taken as a whole is moderate and is tampered by the sea breeze which blows for eight months of the year from March to October, making the hot weather comparatively cool. During the monsoon period, the sky is cloudy, but there is very little precipitation. The climate in summer is generally moist and humid. The cold weather in Badin starts from the beginning of November when a sudden change from the moist sea breeze to the dry and cold north-east wind, as a natural consequence, an immediate fall in temperature. The maximum temperature in the hot weather does not usually exceed 40^{0}C, while the minimum reading in winter does not fall below 8^{0}C. The autumn sets in September and lasts for 1/2 months.

Irrigation

The water originating from Sukkur and Kotri barrages irrigates Badin district. The area being fed by Kotri barrage is further divided into perennial and non-perennial system of irrigation. The particulars of canals, area under command and discharge capacity is given in table:

IRRIGATED LAND ITS SOURCE

S. No.	Source/Canal	Area under command (In acres)	Discharge of Irrigational Water (in cusecs)
1	Guni Canal (Non-perennial)	375,8 1 5	5,630
2	Phuleli Canal (Non-perennial)	414600	5,796
3	Akram Wah (Non-perennial)	416,675	2,906
4	Nasir Canal (Perennial)	302,012	876

Source: Deputy Commissioner Office, Badin.

LBOD and its impacts in the region

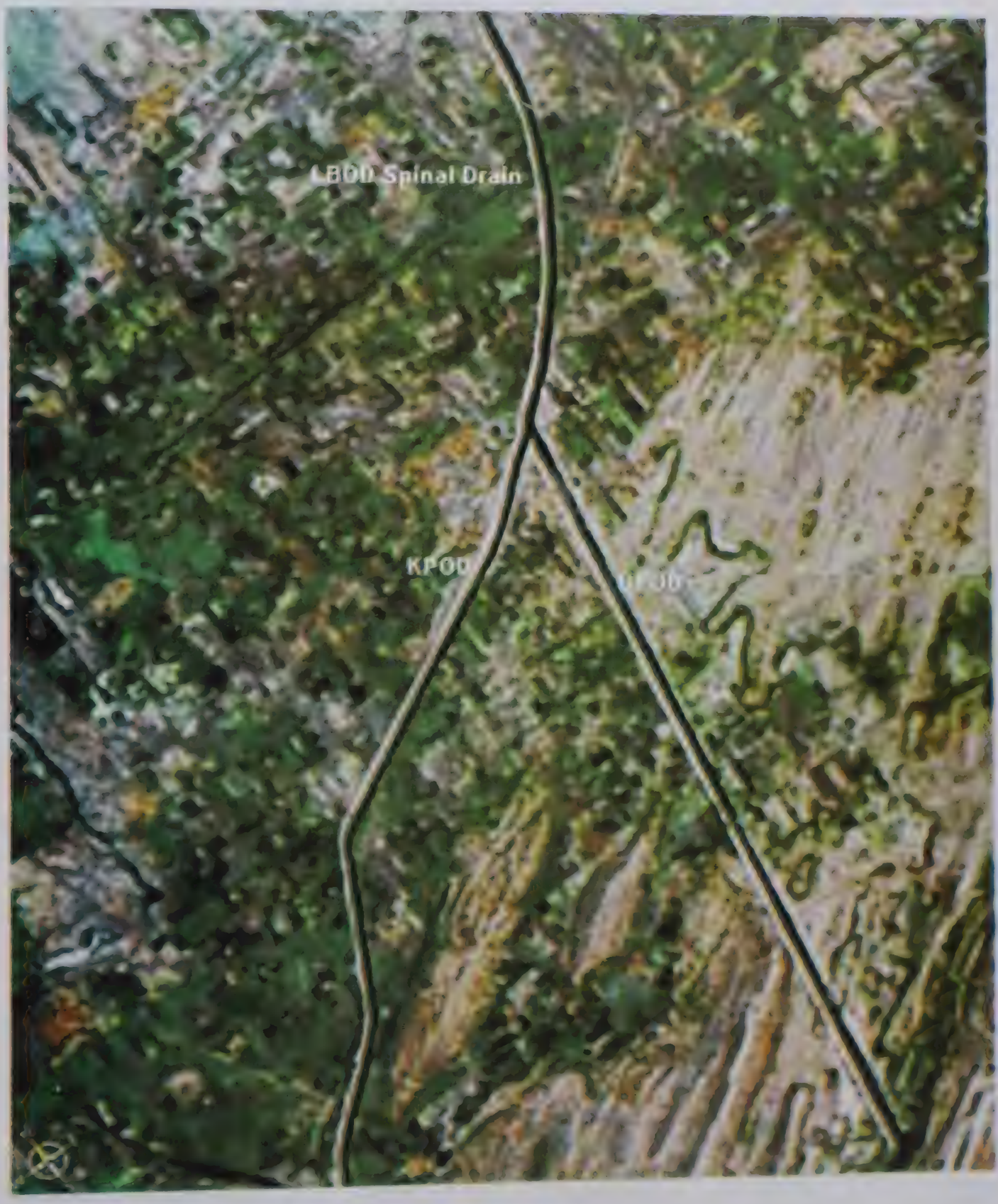
Left Bank Outfall Drain (LBOD) project is one of the world's largest drainage schemes in Sindh. It was designed to drain saline and surface water, storm runoff, and municipal wastewater from three districts including Nawabshah, Sanghar, and Mirpurkhas of Sindh province. The Project was intended to improve irrigation and drainage conditions for an area of about 516,500 hectares in the southeastern Sindh. It comprises 2.5 million hectares catchments of the LBOD (Asian Development Bank).

In the early 1960s, the Government of Pakistan undertook a major program to provide drainage to relieve water logging and salinity in the 18 million hectares irrigation system in the Indus River plain. The works started in 1986 on the Left Bank Outfall Drainage (LBOD) project and its 80-85% work was completed in December 1999, seven years after scheduled period.

The central feature of the LBOD is the Spinal drain, which connects the drainage network to the sea through a Tidal Link. The Spinal drain collects surplus drainage and distribute it through a weir (barrier built across the river in order to control the water) to other two branch drains, the Kadhan Pateji Outfall Drain (KPOD) and the Dhoro Puran Outfall Drain (DPOD). DPOD drains the effluents in lake Shakoor, while the KPOD drains into the sea through 26 miles long canal, named as the Tidal Link. The Tidal link was launched to save the coastal belt near Badin from the saline effluent of the upper Sindh, but unfortunately, it lasted for less than one year thereby the efficiency of the whole project remained inefficient.

Due to this, the ecology of fresh and saline water lakes are being affected, as their land area is expanding day by day. It was 6,058 acres in 1954, which extended to 41,220 acres in 1977. How ever its area has increased rapidly during 1998 to 2000 after the proper functioning of the LBOD and has reached up to 60,000 acres at present. Therefore, the municipal and agricultural excessive water, which is already contaminated, is disturbing the lakes and marine ecology to greater extent. The LBOD project was to bring drainage effluents from the upstream and dispose it of into the Arabian Sea via the Tidal Link Canal. However, due to several technical problems the drainage effluents instead of going into the sea started destroying lands and internationally recognized wetlands. The project-induced problems like flooding, sea intrusion, loss of crops and agricultural land, reduction in fish catches and loss of lives but nobody cared to overcome these faults. 32 people were killed as a result of the LBOD since it was launched in 1999 while 50,000 acres of agricultural land in eight union councils had been wasted by salinity or water-logging. 10,000 fishermen lost their livelihood; four vast wetlands - two of them internationally recognized - had been degraded owing to damage to the biodiversity, and about 52 species in the area had also been damaged.

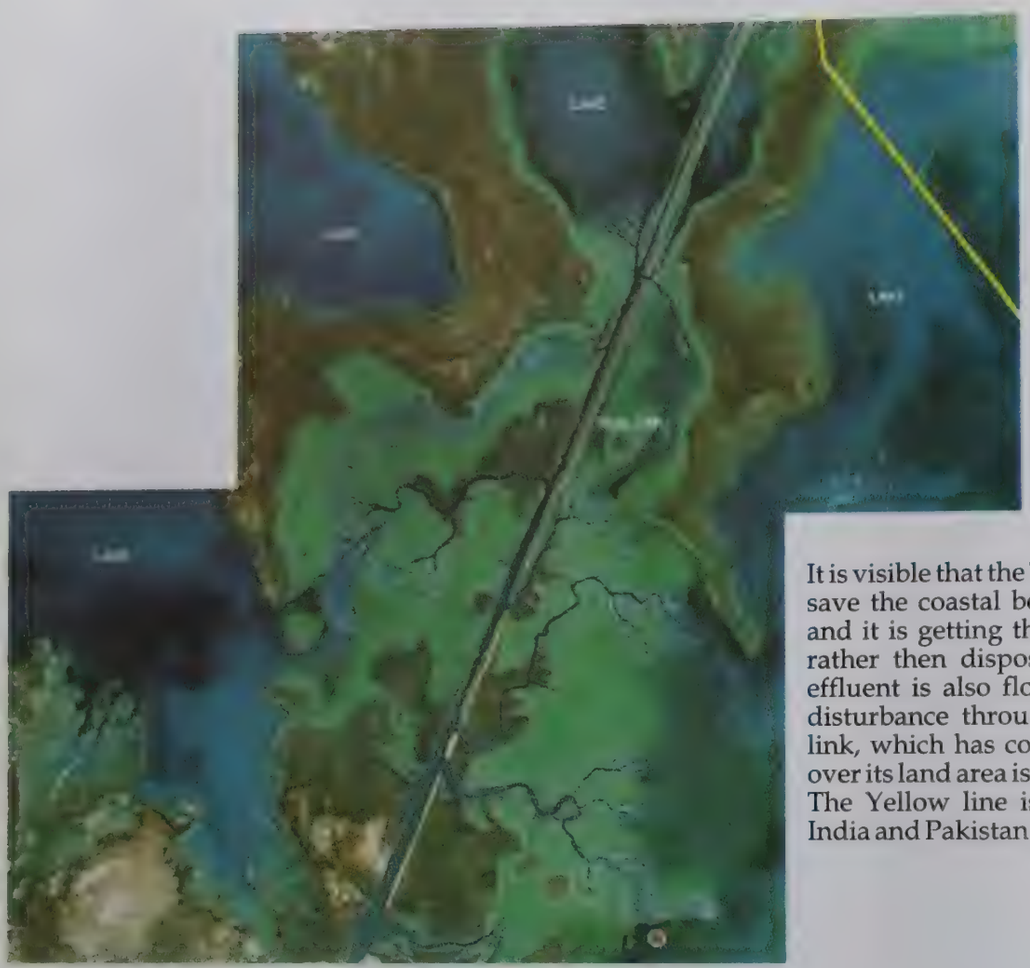
During 2004 monsoon, rain and floodwater could not be disposed of through the drain, which caused seepage and salinity in the region. The simultaneous rains in the catchments area of four districts; Badin, Mirpurkhas, Sanghar and Nawabshah in July 2003 had made it difficult to handle the situation. The high tide effect on the Kadhan Padeji Outfall Drain and as the Choliri Weir had been washed away and the tidal link was in falling to pieces condition, the sea resisted effluent acceptability and the increased water pressure, after growers closed their watercourses, resulted in several breaches in the drain. Eight of the 12 breaches occurred in the same vicinity where in 1994, 54 breaches had occurred, mostly at the junction of the KPOD and Dhoro Puran Outfall Drain and its crest as the natural course of water had been obstructed.



SATELLITE IMAGE OF TIDAL LINK 2006

LBOD, KPOD and DPOD out fall drains as seen from space

This image shows that the spinal drain divides into KOPD at western side and DPOD on its eastern side, which disposes the efflucent into lake shakoor through Dhoro Puran



It is visible that the Tidal link that was launched to save the coastal belt of Badin is fully damaged and it is getting the seawater during high tides rather then disposing the effluent in sea. The effluent is also flowing into lakes without any disturbance through the breaches of the Tidal link, which has contaminated these lakes; more over its land area is expanding day by day.
The Yellow line is the boundary line between India and Pakistan.

Tidal link Dhands prior to construction of the outfall drain, the end of KPOD is just visible to North east of the Pateji dhand. Note the cultivation around Northern and eastern margins of dhands; the white areas are surface salt deposits.

Geographical locatioon of The Water Sample Collection, in Badin District, Taluka Gloarchi & Badin

S. No	Area of water sample collection	Geographical Location
1	KPOD (North)	24° 24.88N 69° 00.46E
2	KPOD (South)	24° 24.845N 69° 00.471E
3	Zero KPOD	24° 17.190N 68° 44.045E
4	KPOD RD-15	24° 18.661N 68° 46.773E
5	Sh Samado Creek	24° 19.846N 68° 75.538E
6	A. R. Jat irrg	24° 22.67N 68° 51.62E
7	Tidal Link	24° 17.403N 68° 36.784E
8	HHajjam (irrg: water)	24° 21.286N 68° 47.462E
9	KPOD Lake Bakrar	24° 17.197N 68° 44.021E
10	A. H.shah drain to lake Narahri near bridge	24° 24.28N 68° 39.94E
11	Ameer Hyder and Punjah mori drain entering in lake Narahri	24° 24.64N 68° 39.81E
12	Link Drain joins KPOD	24° 30.45N 69° 21.80E
13	Two drains joining at village Mehar Mallah	24° 23.93N 68° 3.36E
14	Punjah mori D joining Ameer shah drain	24° 24.26N 68° 39.35E
15	Lake Narahri	24° 22.50N 68° 39.64E
16	Ahmed Rajo Irrg: Water	24° 26.05N 68° 37.38E
17	Haji Hajjam Hand pump	24° 21.302N 68° 47.462E
18	Missri Mallah irrg: water	24° 23.00N 68° 50.76E
19	Qazi Wah after crossing Badin City irrg: water	
20	Qazi Wah before crossing Badin City irrg: water	24° 38.15N 68° 51.03E
21	DPOD near bridge	24° 51.30N 68° 56.06E
22	Water supply after purification Badin city	24° 21.55N 69° 04.03E
23	Water supply reservoir Badin city	24° 39.13N 68° 50.54E
24	Chlorine mixing in water supply	24° 39.13N 68° 50.54E
25	Ali Bengali irrg: water	24° 39.13N 68° 50.54E
26	Ahmed RajoHand pump	24° 41.644N 68° 38.940E
27	Qasim Mallah irrg: water	24° 37.625N 68° 50.561E
28	Sem drain Near Khoski sugar mill	24° 05.49N 68° 16.42E
29	Sem drain near bridge at Nindo Khoski road	24° 24.98N 68° 49.41E
30	Ansari Sugar mill effluent	----------
31	Khoski sugar mill effluent	24° 38.328N 69o 04.346E
32	LBOD spinal Drain	24° 37.486N 69° 07.788E
33	DPOD before weir	24° 36.606N 69° 10.578E
34	Pangrio sugar mill	24° 36.521N 69° 10.687E
35	Goni drain at RD123 near bridge (it collects 2 sugar mills & leghari and Khaskell oil field effluents)	24° 33.322N 69° 09.879E
36	Khaskelly oil field effluent at drain	24° 44.469N 69° 04.370E
37	Khaskelly oil field effluent at falling source line	24° 41.644N 68°.38.940E
38	Karhio town Hand pump	24° 47.732N 68° 34.552E
39	Mirza sugar mill effluent	24° 47.732N 68° 34.552E
40	Army sugar mill	24° 48.652N 68° 36.539E
41	Karhio to Leghari Road Hand Pump	24° 52.679N 68° 43.592E
42	Sep water from oil at Khaskelly oil field	24° 31.377N 68° 56.609E

Details of water sample collections at the field in Thatta District, Taluka Kharochan & Keti Bandar

S. No	Area of water sample collection	Geographical Location
1	Ali Patni, Yaqoob, G. Hussain Otho.	24 07.92N 67 36.28E
2	Umar Patni	24 07.52N 67 35.95E
3	Hassan Shah	24 08.06N 67 35.75E
4	Suleman Gugho, Haji Mosa Katiar, Dilawar Khan sholani, Mohammad Ali Bhurj	24 09.25N 67 31.46E
5	Syed Ghulam Hyder Shah	24 07.93N 67 37.56E
6	Haji Shah Bukhari	24 08.91N 67 34.98E
7	Natho Ghambheer	24 07.38N 67 35.85E
8	Adam Sholani, Noor Sholani, Haji Qasim sholani, Ali Mohad Sholani, Qasim Khaskely.	24 04.21N 67 33.69E
9	Abdullah Katiar	24 07.88N 67 37.65E
10	Juman Mallah	24 08.10N 67 37.94E
11	Keti Bandar, Allah Dino shah, Qasim Shah, Pir dino Shah, Ali Mohd Shah,Zangi, Mohammad Jat, haji Aleem Sholani, Ishaq sheedi,	24 07.92N 67 56.28E

DETAILS OF THE PHYSICAL PARAMETERS OF WATER THAT WAS ANALYZED

Dissolved Oxygen

Dissolved oxygen analysis, measures the amount of gaseous oxygen (O2) dissolved in an aqueous solution. Oxygen gets into water by diffusion from the surrounding air, by aeration (rapid movement), and as a waste product of photosynthesis. Dissolved gases are present in surface and groundwater, the major gases concern are oxygen and carbon dioxide. As compared to ground water the surface water is more affected by human activities. If the organic matter such as untreated human or animal waste is placed into the surface, water body, dissolved oxygen level decreases as micro-organisms grows. There are two main sources of dissolved oxygen in stream water: the atmosphere and photosynthesis. Waves and tumbling water mix air into the water where oxygen readily dissolves until saturation occurs. Aquatic plants and algae also introduce oxygen as a byproduct of photosynthesis dissolved oxygen (DO) in natural and wastewater depends on the physical, chemical and biological activities in the water bodies. The analysis for the D.O. is important in water pollution control and wastewater treatment. The measurement of dissolved oxygen in water is parts per million (ppm), which is the number of oxygen molecules (O_2) per million total molecules in a sample.

Environmental Impact

Adequate dissolved oxygen is necessary for good water quality. Oxygen is a necessary element to all forms of life. Natural stream purification processes require adequate oxygen levels in order to provide for aerobic life forms. Dissolved oxygen levels below 3 ppm are stressful to most aquatic organisms. Levels below 2 or 1 ppm will not support fish. Fish growth and activity usually require 5-6 ppm of dissolved oxygen. Low dissolved oxygen level indicates an excessive demand on the oxygen of the system. The build up of organic material from human activities is one source of oxygen depletion. Microorganisms in the stream consume oxygen as they decompose sewage,

urban and agricultural runoff, and discharge from food-processing plants, meat-packaging plants and dairies. Natural organic materials, such as leaves, accumulate in the stream and create an oxygen demand as they decompose. Some pollutants produce direct chemical demand on oxygen in the water. Dissolved oxygen is consumed in the oxidation-reduction reactions of introduced chemical compounds, such as nitrate (NO_3^{1-}) ammonia (NH_4^{1+}) sulfate (SO_4^{2-}) and sulfite (SO_3^{2-}), and ferrous (Fe^{2+}) and ferric (Fe^{3+}) ions.

Conductivity

The ability of an aqueous solution to carry an electric current is called conductivity. The current is conducted in the solution by the movement of ions. Conductivity increases with increasing amounts and mobility of ions. In natural water, the dissociation of inorganic compounds is the main source of ions in the solution. Therefore, measuring conductivity reveals the concentration of dissolved salts in water. Conductivity is also affected by heavy metal ions released into water.

pH

The pH of a liquid is the negative logarithm of the concentration of hydrogen ions (catinos) in the solution.

$pH = -\log [H^+]$

Because the pH scale is logarithmic, every single unit change in pH actually represents a ten-fold change in the number of hydrogen ions in a solution.

The pH of natural water depends on several factors, which include the bicarbonate buffering system, types of rock, types of soil, and nature of discharged pollutants. The concentration of carbonates and carbon dioxide is the main influence on the pH of clean water. High concentrations of bicarbonate produce alkaline waters (high pH), while low concentrations usually produce acidic waters (low pH). Acidic and alkaline compounds can be weathered into the stream from the different types of rock present. When limestone ($CaCO_3$) is present, carbonates can be released, affecting the alkalinity of the water. The types of soil in the drainage area also affect the pH. Drainage water from forests and marshes is often slightly acidic, due to the presence of humic acids produced by decaying vegetation. Nitrogen oxides (NO, NO_2) and sulfur dioxide (SO_2) from automobile and power plant emissions are converted into nitric acid (HNO_3) and sulfuric acid (H_2SO_4) in the atmosphere. These acids can affect the pH of streams by combining with moisture in the air and falling to the earth as acid rain or snow. Surface waters can sometimes act as weak buffer solutions depending on the concentrations of carbonates and bicarbonates.

The pH values of natural surface waters usually range from 5.5 to 8.5. Extremely high (9.6) or low (4.5) values are unsuitable for most aquatic organisms. Young fish and immature stages of aquatic insects are extremely sensitive to pH levels below 5.

Changes in pH can also affect aquatic life indirectly by altering other aspects of water chemistry. Low pH levels accelerate the release of heavy metals from sediments on the stream bottom. The heavy metals can reduce the chance of survival of most aquatic organisms.

Environmental Impact

A pH range of 6.0 to 9.0 appears to provide protection for the life of freshwater fish and bottom dwelling invertebrates. The table below gives some special effects of pH on fish and aquatic life.

Limiting pH Values

Minimum	Maximum	Effects
3.8	10.0	Fish eggs could be hatched, but deformed young are often produced
4.0	10.1	Limits for the most resistant fish species
4.1	9.5	Range tolerated by trout
---	4.3	Carp die in five days
4.5	9.0	Trout eggs and larvae develop normally
4.6	9.5	Limits for perch
---	5.0	Limits for stickleback fish
5.0	9.0	Tolerable range for most fish
---	8.7	Upper limit for good fishing waters
5.4	11.4	Fish avoid waters beyond these limits
6.0	7.2	Optimum (best) range for fish eggs
---	1.0	Mosquito larvae are destroyed at this pH value
3.3	4.7	Mosquito larvae live within this range
7.5	8.4	Best range for the growth of algae

The most significant environmental impact of pH involves synergistic effects. Synergy involves the combination of two or more substances that produce effects greater than their sum. This process is important in surface waters. Runoff from agricultural, domestic, and industrial areas may contain iron, aluminum, ammonia, mercury or other elements. The pH of the water will determine the toxic effects, if any, of these substances. For example, 4 mg/l of iron would not present a toxic effect at a pH of 4.8. However, as little as 0.9 mg/l of iron at a pH of 5.5 can cause fish to die. Synergy has special significance when considering water and wastewater treatment. The steps involved in water and wastewater treatment require specific pH levels. In order to coagulation (a treatment process) to occur, pH and alkalinity must fall within a limited range. Chlorination, a disinfecting process for drinking water, requires a pH range that is temperature dependent.

Results and Discussion

Water samples for physico-chemical analysis were collected in polystyrene bottles of 600ml capacities. Before collecting the samples, the bottles were washed properly first with water and then with distilled water. HNO_3 acid was used as preservatives in the sampling bottles for trace elements. Water samples were collected from hand pumps after purging of the hand pump. The purging was carried out by making one stroke for every foot of depth (A hand pump having 25 feet of depth, needs 25 strokes for its purging). The water samples were collected during the month of September. The water samples carried out to analyze the water quality of surface that drains effluent down to the sea. Water at KPOD near bridge was observed flowing towards tidal link and was considered as representative of the drainage water. It was observed that water was brackish with salinity of 2.3 PPT, electric conductivity 4.33 m µS/cm and TDS 2.35g/L. The water was considered not suitable for domestic and agricultural purpose.

However the pH 7.89-8.09 and dissolved oxygen 0.5- 3.48 ppm and therefore were within acceptable limits for biological life inhibiting in the water. While below the KPOD toward tidal link seawater encroaches towards tidal link and some increase in salinity, conductivity and TDS [See table- 3]. At zero point the electrical conductivity, salinity and total residue were measured at the surface of the water. The conductivity 6.72 µS/cm, salinity 3.8 and TDS 3.64 g/L. Electrical

conductivity, salinity and TDS increased rapidly at tidal link Shah Samdro creek due to the greater influence of sea water during high tide at Arabian Sea.

It was found that the sugar mill waste (untreated) water is also disposed off into the out fall drainage, the pH of this water was 4.5 and the dissolved Oxygen was 0.23 ppm, TDS 4.88 g/l, E.C. 8.93 µS/cm and the salinity was recoded 5 ppt. Except this almost all six sugar mills disposes their waste water directly to the drains which is threatening the lakes (Internationally recognized), Khaskelly Oil Field is also disposing its untreated waste through drain into lake Nrahri, and contributing to contaminate the lake. (See Table- 5)

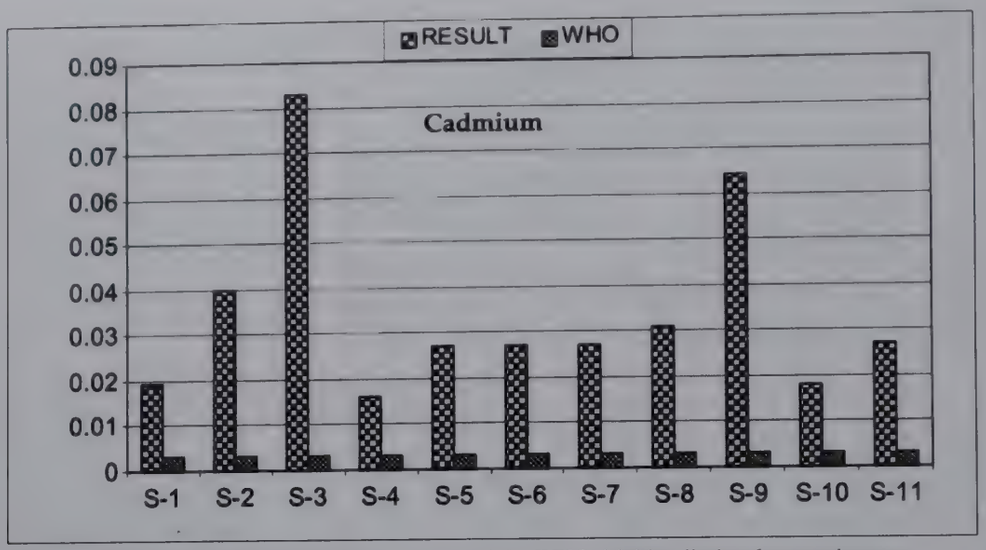
Same the case was found at the Kharochan and Keti Bandar areas, where the seawater encroaches inland twice in 24hrs and therefore makes the water brackish, the pH, ranges between 7- 8. The hand pumps were installed at the banks of freshwater courses, according to local people these hand pumps give fresh water as the water courses are flowing with fresh water and becomes brackish as it dries. For the drinking water standard of Who (see table-4) the parameters that are bold have been analyzed to compare the regional water quality. Chemically parameters were set for the samples collected from Thatta district at the center resource Lab University of Peshawar. The Cadmium level was found high in almost all the samples as compared to WHO standard but the water samples collected from Hassan shah and Abdullah Katiar were of highest values. While the Copper was found bellow the limits and the Lead and Nickel was also beyond the limits (see the charts).

Preventive measures

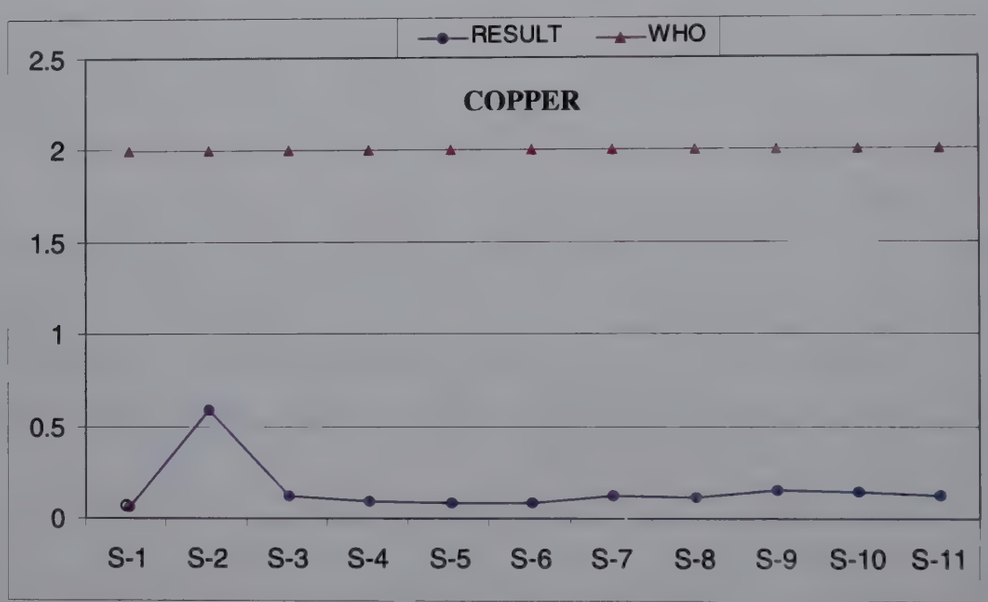
Water-borne epidemics and health hazards in the aquatic environment are mainly due to improper management of water resources. Proper management of water resources has become the need of the hour as this would ultimately lead to a cleaner and healthier environment. In order to prevent the spread of water-borne infectious diseases, advocacy and awareness should be arranged in the region, as people should take adequate precautions.

Details of water smple collections at the field in Thatta Distrcit, TalukaKharochan & Keti Bandar

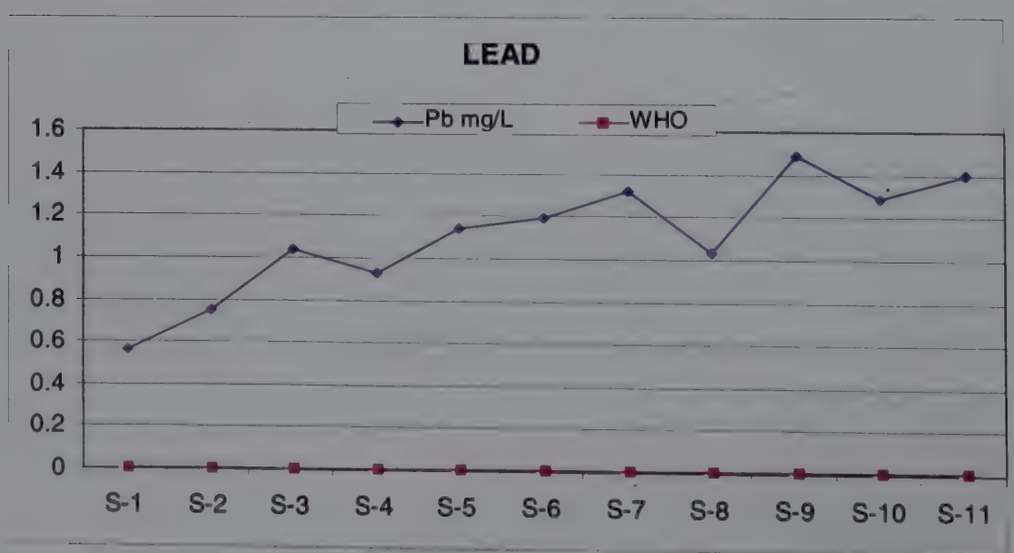
S. No	Area of water sample collection	Geographical Location
1	Ali Patni, Yaqoob, G. Hussain Otho.	24 07.92N 67 36.28E
2	Umar Patni	24 07.52N 67 35.95E
3	Hassan Shah	24 08.06N 67 35.75E
4	Suleman Gugho, Haji Mosa Katiar, Dilawar Khan sholani, Mohammad Ali Bhurj	24 09.25N 67 31.46E
5	Syed Ghulam Hyder Shah	24 07.93N 67 37.56E
6	Haji Shah Bukhari	24 08.91N 67 34.98E
7	Natho Ghambheer	24 07.38N 67 35.85E
8	Adam Sholani, Noor Sholani, Haji Qasim sholani, Ali Mohad Sholani, Qasim Khaskely.	24 04.21N 67 33.69E
9	Abdullah Katiar	24 07.88N 67 37.65E
10	Juman Mallah	24 08.10N 67 37.94E
11	Keti Bandar, Allah Dino shah, Qasim Shah, Pir dino Shah, Ali Mohd Shah,Zangi, Mohammad Jat, haji Aleem Sholani, Ishaq sheedi,	24 07.92N 67 56.28E



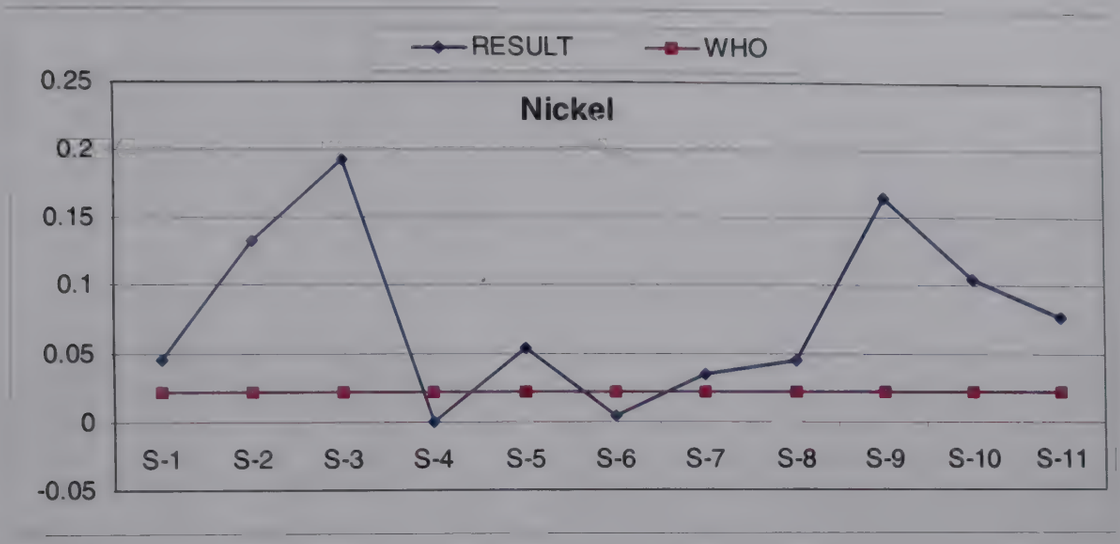
The cadmium level in ail the samples were beyond the WHO drinking limits, the samples were taken from the drinking water.



This chart shows that the Copper level is under admissible limit



The lead in the drinking water in both the Kharo chan and Keti Bandar is very high in all sample collection locations, as compared to WHO standards.



At the villages, Suleman Gugho, Haji Mosa Katiar, Dilawar Khan sholani, Mohammad Ali Bhurj and Haji Shah Bukhari the Nickel level is under the who limit, except this at all other villages it is beyond the admissible limit as shown in chart.

WHO Guidelines for drinking water standards chemicals of health significance

Inorganic	mg/l
Cadmium	0.003
Copper	2.000
Lead	0.010
Nickel	0.020

Drinking water standards (us, epa)

Contaminants	MCLG (mg/L)	Potential Health Effects from Ingestion of Water
Cadmium	0.005	Kidney effects
Copper	1.3	Gastrointestinal irritation
Lead	Zero	Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities. Adults: Kidney problems; high blood pressure, Nervous system damage
Nickel	0.020	

Note: - Maximum Contaminant Level Goal (MCLG) - The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.

Cause	Water-borne diseases
Bacterial infections	Typhoid, Cholera, Paratyphoid fever, Bacillary dysentery
Viral infections	Infectious Hepatitis (jaundice), Poliomyelitis
Protozoal :nfections	Amoebic dysentery

Results of Physical Parameters of water sample

S. No.	Area	pH	Temp °C	D.O ppm	E.C µS/cm	TDS g/l	SAL ppt
1	KPOD (North)	7.89	28	0.5	4.33	2.32	2.3
2	KPOD (South)	8.09	28	3.48	4.41	2.38	2.3
3	Zero KPOD	8.2	32	2.49	6.72	3.64	3.8
4	KPOD RD-15	8.4	30	2.65	5.51	2.98	3
5	Sh Samado Creek	8.85	34	2.47	2.3	1.23	1.1
6	A. R. Jat irrg	8.6	26	2.35	826	439	0.4
7	Tidal Link	8.4	28	2.54	3.36	1.81	1.7
8	HHajjam (irrg: water)	8.06	30	0.14	347	185	0.2
9	KPOD Lake Bakrar	8.3	38	2.6	6.23	3.38	3.3
10	A. H.shah drain to lake Narahri near bridge	8.18	28	0.1	6.22	3.38	3.5
11	Ameer Hyder and Punjah mori drain entering in lake Narahri	8.6	30	0.17	6.27	3.4	3.4
12	Link Drain joins KPOD	8.3	28	2.16	1859	997	0.9
13	Two drains joining at village Mehar Mallah	8.5	29	0.14	6.84	3.69	3.7
14	Punjah mori D joining Ameer shah drain	8.5	28	1.81	5.67	3.07	3.1
15	Lake Narahri	8.6	28	1.72	6.8	3.69	3.7
16	Ahmed Rajo Irrg: Water	8.2	29	0.81	692	368	0.3
17	Haji Hajjam Hand pump	7.14	28	2.82	1188	632	0.6
18	Missri Mallah irrg: water	8.5	30	0.11	398	2.11	0.2
19	Qazi Wah after crossing Badin City irrg: water	8.3	28	0.49	371	197	0.2
20	Qazi Wah before crossing Badin City irrg: water	8.36	28	2.77	347	185	0.2
21	DPOD near bridge	8.7	28	0.28	8.41	4.58	4.6
22	Water supply after purification Badin city	8.4	30	2.83	367	195	0.2
23	Water supply reservoir Badin city	8.6	30	2.93	364	193	0.2
24	Chlorine mixing in water supply	xx	xx	2.97	3.01	162	1.6
25	Ali Bengali irrg: water	7.9	30	3.52	384	204	0.2
26	Ahmed RajoHand pump	7.7	34	2.82	541	288	0.3
27	Qasim Mallah irrg: water	8.3	34	4.83	315	166	0.2
28	Ansari Sugar mill effluent	4.55	33	0.23	8.93	4.88	5
29	Sem drain near bridge at Nindo Khoski road	6.2	23	0.13	6.3	3.45	3.5
30	Sem drain Near Khoski sugar mill	6.3	29.5	0.41	786	418	0.4
31	Khoski sugar mill effluent	6.72	26.5	0.15	871	464	0.4
32	LBOD spinal Drain	6.4	22.8	0.21	7.81	4.25	4.3
33	DPOD before weir	6.45	27	0.17	7.92	4.34	4.5
34	Pangrio sugar mill	6.5	28.6	0.41	1752	938	0.8
35	Goni drain at RD123 near bridge (it collects 2 sugar mills & leghari and Khaskell oil field effluents)	6.45	25.5	0.11	7.2	3.92	3.9
36	Khaskelly oil field effluent at drain	6.48	26	0.12	2.68	1.43	1.4
37	Khaskelly oil field effluent at falling source line	6.48	26	0.25	2.36	1.27	1.1
38	Karhio town Hand pump	6.75	25	1.8	1372	731	0.7
39	Mirza sugar mill effluent	5.8	25.4	0.17	996	530	0.5
40	Army sugar mill	6.55	32.7	0.14	1368	730	0.7
41	Karhio to Leghari Road Hand Pump	3.74	32.3	1.81	1015	543	0.5
42	Sep water from oil at Khaskelly oil field			0.07	12.75	7.05	7.2

SOIL IN BADIN AREA

Soils represent the single-most important natural resource on which human existence and prosperity depend. A large variety of soils are found in the region, which varies significantly in kind and distribution. The soil samples were collected from Badin district from various locations, the samples were taken at the depth of 9 inches at top layer and 9 inches after the first sample the total thickness of 18 inches with "A" and "B" sample from cultivated lands and uncultivated lands. It was found that the salinity in soil are more saline at the southern half Badin and Golarchi (Shaheed Fazil Raho) talukas of the district as compared to northern.

Physical Parameters of Soils Group-A

S. No.	Area	Status of Land	Color	Composition	PH	TDS g/L	SAL ppt	E.C µS/cm	Risistivity
1	Near village Haji Hajjam	Un-cultivated	Brown	Silt + clay	7.11	2.66	2.7	203	4.92
2	Near village Ali Bengali	Cultivated	Blackish	Clay	6.98	2.4	2.4	224	4.45
3	Near village Allah Rakhio Jat	Cultivated	Dark brown	Clay + silt	6.83	2.17	2.2	249	4.02
4	Natho Lund 300m away at left side of KPOD	Cultivated	Brownish	Clay	6.97	690	0.6	774	1292
5	Near village Qasim Mallah	Cultivated	Brown	Clay	6.89	2.75	2.8	194	5.09
6	Guni Near road east side	Cultivated	Brownish	Clay	7.1	2.66	2.7	203	4.93
7	३ Near village Ahmed Rajo	Cuitivated	Blackish Brown	Clay	7.02	765	0.7	698	1433
8	Near lake Narahri	Un-cultivated	Brown	Silt+ clay	7.01	1.56	1.5	343	2.92
9	Near tower at road side	Un-cultivated	Brown	Silt + clay	7.12	2.99	3	181	5.53
10	Near Tando Bago road	Cultivated	Brownish	Clay	7.03	322	0.3	1649	608
11	Near dewan sugar mill Khoski	Cultivated	Dark brown	Clay	7.03	298	0.3	1785	562
12	Village Jhangi abt 300m from LBOD spine	Cultivated	Brown	Clay + silt	6.95	879	0.8	605	1648
13	Near DPOD after weir abt 400m	Un-cultivated	Dark brown	Silty	6.91	1.85	1.8	290	3.45
14	Near Pangrio	Cultivated	Brown	Silty + clay	7.02	313	0.3	1697	589
15	Near Pangrio Khoski road	Cultivated	Brownish	Sandy	6.95	1.69	1.6	318	3.15
16	Bachal Panhwar	Cultivated	Black brown	Clay	7.09	688	0.6	777	1285
17	Near village Tarai	Cultivated	Brown	Clay	7.01	325	0.3	1638	611
18	Near village Achar Samejo	Cultivated	Brown	Clay	7.07	652	0.6	818	1223
19	Near village Juna	Cultivated	Blackish	Clay + Silty	7.07	276	0.3	1926	519
20	Near leghari oil field	Cultivated	Brownish	Silty + clay	7.02	778	0.7	687	1458
21	Near Bawani sugar mills	Cultivated	Blackish	Clay + silt	7.07	388	0.4	1374	728
22	Near Lawari sharif south ward	Cultivated	Dark brown	Clay	6.97	1068	1	503	1999
23	Near Army sugar mills	Cultivated	Dark brown	Clay	6.94	2.11	2.2	254	3.94

Physical Parameters of Soil Group-B

S. No	Area	Status of Land	Color	Composition	pH	TDS g/L	SAL ppt	E.C µS/cm	Risistivity
1	Near village Haji Hajam	Un-cultivated	Brown	Silt + clay	6.85	1.99	2	269	3.72
2	Near village Ali Bengali	Cultivated	Blackish	Clay	6.95	771	0.7	269	3.72
3	Near village Allah Rakhio Jat	Cultivated	Dark brown	Clay + silt	7.11	2.45	2.5	220	4.55
4	Natho Lund 300m away at left side of KPOD	Cultivated	Brownish	Clay	6.98	1.29	1.2	414	2.41
5	Near village Qasim Mallah	Cultivated	Brown	Clay	6.92	2.77	2.8	195	5.14
6	Guni Near road east side	Cultivated	Brownish	Clay	7.17	3.16	3.2	171	5.86
7	Near village Ahmed Rajo	Cultivated	Blackish Brown	Clay	7	798	0.7	669	1496
8	Near lake Narahn	Un-cultivated	Brown	Silt+ clay	7.05	2.34	2.3	229	5.37
9	Near tower at road side	Un-cultivated	Brown	Silt + clay	7.01	2.26	2.2	238	4.2
10	Near Tando Bago road	Cultivated	Brownish	Clay	7.04	361	0.3	1470	680
11	Near dewan sugar mill Khoski	Cultivated	Dark brown	Clay	7	639	0.6	834	1198
12	Village Jhangi abt 300m from LBOD spine	Cultivated	Brown	Clay + silt	7.01	310	0.3	1720	582
13	Near DPOD after weir abt 400m	Un-cultivated	Dark brown	Silty	7.03	413	0.4	1288	777
14	Near Pangrio	Cultivated	Brown	Silty + clay	7	397	0.4	1340	745
15	Near Pangrio Khoski road	Cultivated	Brownish	Sandy	7.07	436	0.4	1223	817
16	Bachal Panhwar	Cultivated	Black brown	Clay	7.06	469	0.4	1132	881
17	village Tarai	Cultivated	Brown	Clay	6.97	464	0.4	1149	870
18	Near village Achar Samejo	Cultivated	Brown	Clay	7.01	833	0.7	644	1556
19	Near village Juna	Cultivated	Blackish	Clay + Silty	6.95	837	0.8	637	1568
20	Near Jeghar oil field	Cultivated	Brownish	Silty + clay	6.97	592	0.5	892	1146
21	Near Bawani sugar mills	Cultivated	Blackish	Clay + silt	7.5	427	0.4	1244	804
22	Near Lawari sharif south ward	Cultivated	Dark brown	Clay	6.81	2.13	2.1	252	3.97
23	Near Army sugar mills	Cultivated	Dark brown	Clay	7.02	1.17	1.1	463	2.16

Results of Physical Parameters of water sample collected from Kharochan & Keti Bandar

S. No.	Area	pH	Temp °C	D.O pm	E.C µS/cm	TDS g/l	SAL ppt
1	Ali Patni, Yaqoob, G. Hussain Otho.	7.45	31	2.47	2.13	1.16	1
2	Umar Patni	7.6	30	2.83	2.08	1.11	1
3	Hassan Shah	8.3	32	0.09	462	246	0.2
4	Suleman Gugho, Haji Mosa Katiar, Dilawar Khan sholani, Mohammad Ali Bhurj	7.6	30	3.07	1.94	1038	0.9
5	Syed Ghulam Hyder Shah	7.35	30	2.25	4.47	2.4	2.4
6	Haji Shah Bukhari	8.03	27	2.9	789	420	0.4
7	Natho Ghambheer	7.35	30	2.51	5.91	3.2	3.2
8	Adam Sholani, Noor Sholani, Haji Qasim sholani, Ali Mohad Sholani, Qasim Khaskely.	8.2	33	2.61	788	527	0.5
9	Abdullah Katiar	8.4	33	2.61	364	194	0.2
10	Juman Mallah	7.84	33	2.83	781	415	0.4
11	Keti Bandar. Allah Dino shah, Qasim Shah, Pir dino Shah, Ali Mohd Shah,Zangi, Mohammad Jat, haji Aleem Sholani, Ishaq sheedi,	6.6	30	2.88	5.57	3.01	3.1

Chapter 16

CONCLUSION

In the coastal area uncertainty and absence of water in the river bed combined with mismanagement of water resources has caused enormous hardship and there is little or no prospect of change in near future.

It appears very little prospect of improvement of environments for coastal and marine fisheries and related species at least for some time. There is also no prospect of increasing income of coastal communities unless a "crash" program is launched.

The two coastal districts Thatta and Badin are the poorest in Pakistan now and up to 1960 were the most prosperous due to the resources. This has all happened due to drastic diversion of waters of the Indus and its tributaries on the upstream side; construction of irrigation barrages and canals diversion of water from one river to other for irrigation through series of link canals and dams, leading to degeneration of coastal areas and drying river Indus, in which led to sea and tide water pushing many kilometers on up stream side, where from it seeped into fertile fields, turning their ground water saline, increasing soil salinity and destroying agriculture and pasture land. This in simple is consequence of seawater intrusion.

Water flow below Kotri barrage is considered "Waste" even by higher ups in the government, without even analyzing if country had benefited more from diverting waters upstream for agriculture or river waters reaching the coast, where mangroves, crustacean, fish and other flora and fauna created economic boom.

There is exploitation of local resources without benefiting local communities. There have been series of projects, but all side tracks from main issue of fresh water inflow and exploitation of local resources, as well as local communities.

The sea intrusion has completely destroyed Shah Bunder and Keti Bunder has been turned into an island, protected by an embankment and road, which is only its link with the country. These two ghost towns were destroyed not by any earthquake, tornado or floods, but by seawater intrusion.

All this has happened because in Pakistan water is a political issue rather than technical and has national political implications created by those in power against the weak.

Even the Sindh government has admitted that 1.2 million acres have been intruded by seawater in the two districts, though other estimates are not less than 2.0 million acres.

Coastal Development Authorities was created in 1993 to find solutions to the problem of coastal area. Instead they started planting coconut, palm oil and salicornia. All three failed as due to high summer temperatures in Badin and Thatta districts except areas close to coast, flowers of coconut

and palm oil about in 10 weeks of winter and again in 13 weeks of summer, affecting the yield. The coconuts themselves abort before maturity in high heat or cold period and they are marketed for coconut water, considered very healthy drink. Salicornia failed as instead of applying 100% seawater they applied diluted drainage water of low salinity. It grew but did not flower and excuse was given that they had no threshers for it, though it is threshed like mustard manually. The public sector institutions are riddled with inefficiencies, lack of co-ordination, corruption absence of accountability and lack of contacts with stake holders.

At government level power and influence of middle man and contractors is so strong that the government unofficially is under their influence and fishermen of Badin and Thatta have always become poorer to poorer from 1960 onwards.

Fishing right of many wetland and lakes have been given to Pakistan Rangers in both Badin and Thatta Talukas. Rangers appoint their own contractors, who in return exploit fishermen. The latter are not even capable of getting 3 meals a day from salaries paid to them. Rangers control Shakoor dhandh, Adda Khan, Shaikhi Ghari, Cholri lake and Sim Nala, all five major coastal lakes, having salinity less than 27,000 ppm and producing large quantities of fish and shrimps. The fishermen are forced to sell fish to their selected contractors. Contractors pay Rs.15 to 20 per kg of shrimps to the fishermen and then sell it in the Karachi whole sale market at Rs.300 per kg.

There is nothing that Provincial or Local Government can do about it on the plea that Rangers are there to protect the border and coast. Fact is that Rangers and part of defence forces are ruling the country since 1958 and all policies are dictated by Defence Forces.

Contractor system of fisheries by the government has made things easy for the government without realising that, it is responsible for poverty of fishermen of coastal areas.

During negotiation with India through good offices of World Bank on water requirement to the sea. Pakistan-India- and World Bank in 1960 agreed to flow of 17 MAF to sea, for protecting the environment. In 1991 Water Accord this was reduced to about 10 MAF, subject to further studies. No studies were under taken for 14 years and finally arbitrators were appointed who recommended a figure of 8.7 million acres with minimum of 5,000 cusecs in on any day of year. This is about 50% of figure agreed up on by the parties in 1960 and yet Federal Government is in no mood to execute it.

If rule of law is to prevail then following action are to be taken:

- Allowing 8.7 MAF down stream of Kotri with no less than 5,000 cusecs on any day.
- Banning use of illegal nets. Stopping illegal trawling.
- Strictly observing one month ban on prawn fishing during their breeding season.
- Abolishing contract system.
- Ending occupation of lakes etc. by Rangers.
- Fixing royalty on oil production in Badin district and using it for local improvement.

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